

MINERGY CORPORATION
GLASS FURNACE TECHNOLOGY
EVALUATION
INNOVATIVE TECHNOLOGY EVALUATION REPORT

National Risk Management Research Laboratory
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NOTICE

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FOREWORD

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Lee Mulkey, Acting, Director
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ABSTRACT

This report presents performance and economic data for a U.S. Environmental Protection Agency (EPA) Superfund Innovative Technology Evaluation (SITE) Program demonstration of the Minergy Corporation (Minergy) Glass Furnace Technology (GFT). The demonstration evaluated the technology's ability to reduce polychlorinated biphenyl (PCB) and metal concentrations in river sediment.

GFT was developed by Minergy to remove PCBs, other organics, and metals from river sediment. The GFT consists of a dryer, a melter, and an air pollution control system. After drying to about 10percent moisture, the dried sediment is mixed with a flux material to control melting temperatures and improve the physical properties of the glass aggregate product, and introduced into the melter. The sediment is heated in the melter to a temperature of about 1,600 degrees Celsius (°C), at which temperature the sediment is molten. At these high temperatures, PCBs and organic contaminants are destroyed or removed, and metals are encapsulated within the glass matrix. The molten sediment exits the melter into a water-quench bath, where it quickly hardens and shatters to form glass aggregate that, Minergy maintains, has reuse value.

Laboratory tests of sediment samples collected during a pilot dredging project on the Lower Fox River, Wisconsin, indicated that the sediment was suitable for melting using the GFT. A demonstration of an indirect-disk or paddle dryer, the intended type of dryer for a full-scale implementation of the GFT, was conducted by Hazen Research, Inc., at its facility in Golden, Colorado in January 2001. A pilot-scale melter was designed and built at Minergy's facility in Winneconne, Wisconsin, where the GFT demonstration treated a total of about 27,000 pounds of dried sediment in the Summer of 2001.

The primary objective for the GFT technology demonstration was to evaluate the treatment efficiency of PCB destruction or removal by the GFT process during the demonstration period. Results of the demonstration indicate that Minergy's GFT removed 99.9995 percent of the PCB contamination in the sediment.

This technology is potentially applicable at hazardous waste sites where river sediment has been impacted by PCBs, other organics, and metals. Economic data indicate that remediation costs of using GFT are affected by site-specific factors, such as local land prices and site suitability. The cost for treatment using a full-scale treatment facility, constructed at a location in proximity to sediment removal activities, was calculated to be \$38.74 per ton of dredged-and-dewatered sediment (containing about 50 percent moisture). Treatment costs, which are affected by the amount of moisture in the sediment and potential end use of the glass aggregate, are based on operating a melter on an average of 600 tons of sediment per day over a 15-year project life.

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ARARs	Applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
CAA	Clean Air Act
CAMU	Corrective action management unit
°C	Degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminant of concern
Comp	Composite
DOT	Department of Transportation
dryer	Indirect heat disk or paddle dryer (can we delete this one?)
EPA	U.S. Environmental Protection Agency
°F	Degrees Fahrenheit
FS	Feasibility study
GFT	Glass Furnace Technology
GLNPO	Great Lakes National Program Office
Hazen	Hazen Research, Inc.
HSWA	Hazardous and Solid Waste Amendments
ID	Identification
ITER	Innovative Technology Evaluation Report
J	Estimated
kg/hr	Kilogram per hour
kJ	Kilojoule
kWh	Kilowatt-hour
Laboratory	National Risk Management Research Laboratory
LCS	Laboratory control sample
LCSD	Laboratory control sample duplicate
LDR	Land Disposal Restriction

ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Continued)

M	Million
melter	Minergy's pilot-scale melter
Minergy	Minergy Corporation
mg	Milligram
mg/kg	Milligram per kilogram
mg/L	Milligram per liter
MS	Matrix spike
MSD	Matrix spike duplicate
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
ND	Nondetect
NPV	Net present value
O ₂	Oxygen
OMB	Office of Management and Budget
ORD	EPA Office of Research and Development
OSHA	Occupational Safety and Health Act
OSWER	Office of Solid Waste and Emergency Response
oxy-fuel	Oxygen and natural gas mixture
P	Primary
Paradigm	Paradigm Analytical Laboratories
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzodioxin
PCDF	Polychlorinated dibenzofuran
%R	Percent recovery
PPE	Personal protective equipment
ppm	Parts per million
ppt	Parts per trillion
PW	Present worth

ACRONYMS, ABBREVIATIONS, AND SYMBOLS (Continued)

QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RCRA	Resource, Conservation, and Recovery Act
S	Secondary
SARA	Superfund Amendments and Reauthorization Act
SITE	Superfund Innovative Technology Evaluation
SMU	Sediment management unit
SPLP	Synthetic Precipitate Leaching Procedure
SVOC	Semivolatile organic compound
Tetra Tech	Tetra Tech EM Inc.
TE	Treatment efficiency
TEQ	Toxicity equivalent
TER	Technology Evaluation Report
tons/day	Tons per day
TSCA	Toxic Substances Control Act
TSD	Treatment, storage, and disposal
TSS	Total suspended solids
UCL ₉₅	95 Percent upper confidence limit
VOC	Volatile organic compound
WAC	Wisconsin Administrative Code
WDNR	Wisconsin Department of Natural Resources

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EXECUTIVE SUMMARY

The Glass Furnace Technology (GFT) treatment process was developed by Minergy Corporation (Minergy) as an *ex situ* remediation technology to treat river sediment contaminated with polychlorinated biphenyls (PCBs), other organic compounds, and metals. An evaluation of the technology was conducted by the U.S. Environmental Protection Agency (EPA) Superfund Innovative Technology Evaluation (SITE) Program. The demonstration of the GFT, which consisted of a drying process and a melting process, was completed at the Hazen Research, Inc. (Hazen) facility in Golden, Colorado, and Minergy's GlassPack Test Center facility in Winneconne, Wisconsin.

According to the vendor, Minergy, the GFT process was designed to treat contaminated river sediment and is intended for use at any location where dredging and remediation of sediment is prescribed. Although site-specific background data are not relevant to the SITE demonstration, the technology evaluation was conducted on river sediment dredged from the Lower Fox River in Green Bay, Wisconsin.

The purpose of this Innovative Technology Evaluation Report is to present information that will assist Superfund decision-makers in evaluating the GFT for application to hazardous waste site cleanups associated with contaminated river sediment. This executive summary describes the GFT, provides an overview of the SITE evaluation of the technology, discusses evaluation criteria for the GFT, and summarizes SITE evaluation results.

Glass Furnace Technology

The GFT process was developed and configured for this SITE demonstration by Minergy. The demonstration process consisted of two basic steps: sediment drying and dried-sediment vitrification. According to the vendor, a full-scale GFT project will integrate drying and melting operations in a single facility. Both processes were evaluated independently for the SITE demonstration. The dryer evaluation was conducted in Golden, Colorado in January 2001, and the melter evaluation was completed in Winneconne, Wisconsin in August 2001.

The GFT process was designed as an alternative treatment to landfilling for river sediment impacted by PCBs, other organics, and metals. Dewatered sediment is dried, flux is added to control melting temperatures and improve the physical properties of the glass aggregate product, and then the sediment and flux mixture melted at a temperature of about 1,600 degrees Celsius (°C) (2,900 degrees Fahrenheit [°F]), removing or destroying PCBs and organic contaminants, and encapsulating metals. The treated

product consists of black glass aggregate with particles the size of coarse sand. Minergy claims the glass aggregate meets state regulatory criteria for beneficial reuse.

For clarification, this document refers to the indirect heat disc or paddle dryer as the **dryer** and the pilot-scale melter portion of the GFT as the **melter**.

Overview of the GFT Technology SITE Demonstration

River sediment from a pilot dredging project conducted on the Lower Fox River in Green Bay, Wisconsin, was used to demonstrate the GFT. Sediment was delivered to the dryer in dewatered form (45 to 55 percent solids by weight). The purpose of the dryer demonstration was to reduce moisture in the sediment from 50 percent to about 10 percent moisture.

According to Minergy, after researching available sediment drying technologies, it was determined that, because of its low volume of sweep air and low potential for generating dust, a indirect heat disc or paddle dryer unit was the most appropriate drying technology for the GFT treatment process. Because this type of large-scale dryers were not available for rent and the purchase of an appropriately sized unit was too costly for the demonstration, Minergy chose a bench-scale Holoflite® dryer, located at the Hazen facility in Golden, Colorado to be used to dry a small amount of the sediment under very similar conditions to those in a large-scale dryer unit. For the melter to operate at optimal efficiency, the dried sediment must contain no more than 10 percent moisture. Sediment entering and exiting the dryer, air emitted from the dryer, and condensed water from the dried sediment were sampled as part the SITE evaluation of the technology. Data from the dryer evaluation were inadequate to use in the overall technology evaluation because sediment dust was drawn into the dryer vent, the condensate collection vessel, and air sampling equipment, and the PCB congeners analyzed were not the same as those analyzed in the sediment.

The bulk of the sediment was dried in a drum oven at Minergy's facility in Winneconne, Wisconsin. To permit the calculation of the overall efficiency of the GFT, samples were collected from the sediment before and after drying in the drum oven. The melting phase of the process was evaluated using a pilot-scale melter (melter) specifically designed for this SITE evaluation. The sediment, flux, glass aggregate, and waste streams were analyzed for predetermined contaminants of concern (COCs) before and after processing through the glass furnace. COCs included PCBs; dioxins and furans; metals, including mercury; and semivolatile organic compounds. The melter evaluation began in June 2001, but was halted after three days when molten sediment corroded a hole in the refractory brick. The

demonstration was stopped before evaluation sampling was completed. Repairs were made to the melter, and the demonstration was rerun in August without incident.

The SITE demonstration for the GFT was designed with two primary and three secondary objectives to provide potential users of the technology with the information necessary to assess the applicability of the GFT for other similarly contaminated sites.

The primary objectives (P) of the technology demonstration were as follows:

- P1 Determine the treatment efficiency (TE) of PCBs in dredged-and-dewatered river sediment when processed in the Minergy GFT.**
- P2 Determine whether the GFT glass aggregate product meets the criteria for beneficial reuse under relevant federal and state regulations. The aggregate product will be judged to be beneficial with respect to each metal or PCB if the 95 percentile upper confidence limit (UCL₉₅) for the estimated mean (of each metal or PCB) is less than the federal or state regulatory requirements, as applicable.**

The secondary objectives (S) of the technology demonstration were as follows:

- S1 Determine the unit cost of operating the GFT on dredged-and-dewatered river sediment.**
- S2 Quantify the organic and inorganic contaminant losses resulting from the existing or alternative drying process used for the dredged-and-dewatered river sediment.**
- S3 Characterize organic and inorganic constituents in all GFT process input and output streams.**

SITE Demonstration Results

Key findings of the GFT are listed below:

- Analytical data indicate that the GFT was able to significantly reduce PCB contamination in all samples collected. Overall, the GFT successfully removed or destroyed 99.9995 percent of the PCBs in the river sediment, measured as total PCBs.
- The GFT appeared to be capable of decreasing mercury concentrations in the river sediment. Mercury was observed in sediment at a concentration slightly less than 1 part per million (ppm), and it was not detected in the glass aggregate analysis. If not removed by the furnace thermally, the mercury likely was inactivated within the glass matrix. Mercury did not leach from the glass aggregate, as evidenced by the results of the American Society of Testing and Materials (ASTM) and Synthetic Precipitate Leaching Procedure (SPLP) water leach tests.

- The GFT reduced the concentration of dioxins and furans in dried sediment. Total dioxin and furan concentrations in the glass aggregate ranged from 1.8×10^{-6} to 3.8×10^{-6} parts per million (ppm), a reduction of *greater than* 99.9995 percent.
- The GFT produced glass aggregate that met Wisconsin Administrative Code Chapter NR 538 Category 2 criteria and qualified for beneficial reuse under the regulation. This qualification allows a wide range of uses, including as an additive to concrete, a material in floor tiles, and as construction fill.
- Minergy demonstrated the dryer and melter technologies separately. Data collected during the Holoflite® dryer test were not used to determine the TE because of the sediment carry-over into all waste streams and the incompatibility of the PCB congener lists analyzed for the dryer and melter evaluations. The TE was calculated using data obtained from sampling dredged-and-dewatered sediment from roll-off boxes and dried sediment from the drum dryer.
- Samples of the glass aggregate were crushed and subjected to ASTM and SPLP leaching analyses. The results of the leaching tests indicated no detections of contaminants of concern in leachates for either method.
- The air sample probe and the flue of the pilot-scale furnace were occasionally clogged by dust during the furnace operation. Removal of the accumulated dust interrupted air sample collection frequently during the demonstration. Analysis of the dust material indicated the presence of metals such as lead and chromium. Dioxins and furans were detected in very small concentrations (1.0×10^{-5} ppm) in those dust samples.
- Post-carbon treatment air samples show a reduction in PCB congeners and PCDD/PCDF concentrations detected in the melter flue gas samples.
- Based on information from Minergy and observations made during the SITE evaluation, the estimated treatment cost is \$38.74 per ton of dredged-and-dewatered sediment containing 50 percent moisture. Unit costs are based on a 15-year project life expectancy and may depend on the location of the treatment facility, amount of moisture in the sediment, and potential end use of the product.

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA), under the Superfund Innovative Technology Evaluation (SITE) Program, evaluated the ability of the Glass Furnace Technology (GFT), developed by Minergy Corporation (Minergy) of Waukesha, Wisconsin to treat sediment containing polychlorinated biphenyls (PCBs) and metals. This introductory section provides background information about the SITE Program, discusses the purpose of this Innovative Technology Evaluation Report (ITER), and describes the proposed technology. This ITER describes additional information about the SITE Program, the GFT, the SITE demonstration, and Minergy's claims about the technology. The SITE evaluation of the GFT involved testing of two phases, a drying phase and a melting phase. The majority of activities undertaken for this evaluation involved the melting phase of Minergy's technology. Key individuals for this project are listed at the end of this section.

1.1 THE SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION PROGRAM

The primary purpose of the SITE Program is to advance development and implementation and to establish the commercial availability of innovative treatment technologies applicable to Superfund and other hazardous waste sites. The SITE Program was established by the EPA Office of Solid Waste and Emergency Response (OSWER) and the Office of Research and Development (ORD) in response to the 1986 Superfund Amendments and Reauthorization Act (SARA), which recognized the need for an alternative or innovative treatment technology research and demonstration program. The SITE Program is administered by the ORD National Risk Management Research Laboratory in the Land Remediation and Pollution Control Division, headquartered in Cincinnati, Ohio. The overall goal of the SITE Program is to implement procedures of research, evaluation, testing, development, and demonstration of alternative or innovative treatment technologies that can be used in response actions to achieve protection of human health and welfare and the environment. Under the SITE Program, an innovative technology's performance in treating an individual waste at a particular site is evaluated.

The SITE Program consists of four component programs: (1) the Demonstration Program, (2) the Emerging Technology Program, (3) the Monitoring and Measurement Technologies Program, and (4) the Technology Transfer Program. An innovative treatment technology can be evaluated under one of these programs. This ITER for the GFT was prepared under SITE's Demonstration Program. The objective of the Demonstration Program is to provide reliable performance and cost data on innovative technologies so that potential users can assess a given technology's suitability for specific site cleanups. To produce

useful and reliable data, demonstrations are conducted at hazardous waste sites or under conditions that closely simulate actual waste-site conditions.

Technologies are selected for the SITE Demonstration Program through EPA's annual requests for proposals. ORD staff review the proposals to determine which technologies show the most promise for use at Superfund sites. Technologies chosen must (1) be at the pilot- or full-scale stage, (2) be innovative, and (3) have some advantage over existing technologies. Mobile or transportable technologies are of particular interest. Implementation of the SITE Program is an ongoing effort involving EPA's ORD, OSWER, various EPA regions, and private business concerns, including technology developers and parties responsible for site remediation.

EPA and the innovative technology developer establish responsibilities for conducting demonstrations and evaluating the technology. The developer is typically responsible for demonstrating the technology at the selected site and is expected to pay any costs for the transport, operation, and removal of related equipment. EPA is typically responsible for evaluating the performance of the technology during the demonstration. This responsibility includes project planning, site preparation, technical assistance support, sampling and analysis, quality assurance (QA) and quality control (QC), report preparation, information dissemination, and transport and disposal of treated waste materials.

At the conclusion of the demonstration, EPA typically prepares a Demonstration Bulletin (2-page summary), a Technology Capsule (10- to 12-page summary), an ITER, and a Technology Evaluation Report (TER). These reports provide an evaluation of all available information on the technology and analyze its overall applicability to other site characteristics, waste types, and waste matrices. Testing procedures, performance and cost data, and QA/QC standards also are presented. A Demonstration Bulletin for Minergy's GFT was published in August 2002. The ITER is discussed in detail in the following sections, and the TER provides relevant information on the technology, emphasizes key results of the demonstration, and includes detailed analytical results.

1.2 INNOVATIVE TECHNOLOGY EVALUATION REPORT

The ITER is intended for use by EPA remedial project managers, EPA on-scene coordinators, contractors, and other decision makers, who are implementing specific remedial actions. The ITER provides details about the technology, SITE evaluation procedures and findings, and unit cost information to aid in evaluating the technology. In particular, the report includes information on cost and site-specific characteristics, and it discusses advantages, disadvantages, and limitations of the technology.

Each SITE demonstration evaluates the performance of a technology in treating a contaminated material or media. Successful field demonstration of a technology at one site does not necessarily ensure that it will be applicable at other sites. Data from field demonstrations may require extrapolation for estimating the operating ranges in which the technology will perform satisfactorily. Only limited conclusions can be drawn from a single field demonstration. This ITER provides information of the GFT developed by Minergy and includes a comprehensive description of the demonstration and its results.

1.3 PROJECT DESCRIPTION

The GFT process is designed to treat PCB- and mercury-contaminated sediment. The GFT project is funded by a cooperative agreement among between Minergy, Wisconsin Department of Natural Resources (WDNR), and EPA's Great Lakes National Program Office (GLNPO). Because the GFT is not designed to be used on any one particular site, detailed information regarding site location, geology, and hydrology is not necessary for the understanding of this demonstration project.

The GFT was developed by Minergy of Waukesha, Wisconsin. Minergy originally developed vitrification technologies to process wastewater sludge into glass aggregate that, Minergy contends, could be sold as a commercial product. Minergy modified a standard glass furnace to treat river sediment containing PCBs and metals, and the SITE Program evaluated the resultant technology's ability to treat sediment containing PCBs and mercury.

With WDNR oversight and funding from a coalition of six paper companies with ties to the Lower Fox River, called Fox River Group, the sediment used in this evaluation was obtained from the Lower Fox River during the 1999 Sediment Management Unit (SMU) 56/57 pilot dredging project. This project included hydraulic dredging, onshore dewatering, filter pressing, and treatment with lime. The PCB-containing sediment dredged during the project was transported to, and disposed of in, a landfill in Green Bay, Wisconsin. However, approximately 70 tons of sediment was segregated in four roll-off boxes and

stored at the Brown County Landfill for use in the Minergy GFT demonstration. The stockpiled, filter-pressed sediment was characterized as containing approximately 50 percent solids.

The Lower Fox River sediment has been subjected to various studies over the last 15 years. Sediment in the vicinity of SMU 56/57 consists of 60 to 80 percent silt, with lesser amounts (0 to 40 percent each) of sand and clay. PCB concentrations as high as 710 parts per million (ppm) have been detected in samples collected from SMU 56/57. However, analytical results for sediment stockpiles prior to, and immediately following, sediment acquisition for the GFT evaluation indicated PCB concentrations of less than 50 ppm and mercury concentrations of about 1 ppm.

Minergy required that the sediment contain no more than 10 percent moisture for the melter to operate at optimal efficiency. Minergy researched available sediment drying technologies and determined that a indirect heat disc or paddle dryer unit was the most appropriate drying technology for the GFT treatment process. Because no large-scale dryers of this type were available for use, a suitable, bench-scale Holoflite® dryer, located at the Hazen facility in Golden, Colorado, was used to dry a representative amount of sediment under similar conditions to those in a large-scale dryer unit. The dryer unit was configured to allow sample collection of all waste and process streams, including off-gases.

The SITE evaluation of the GFT focused on the melting phase where contaminant reduction would occur. The melting phase of the process was evaluated at a pilot-scale melter that was specifically designed for the SITE evaluation at Minergy's facility in Winneconne, Wisconsin. The sediment, glass aggregate, and waste streams were analyzed for contaminants of concern (COCs) before and after (1) treatment in the bench-test sediment dryer, and (2) processing through the melter. COCs included PCBs; dioxins and furans; metals, including mercury; and SVOCs. Metals were characterized by analysis for the eight Resource Conservation and Recovery Act (RCRA) Toxicity Characteristic metals, which include mercury.

1.4 THE GLASS FURNACE TECHNOLOGY

The following sections provide a general description of the GFT, as well as Minergy's melter and its specific configuration.

1.4.1 General Description of the Glass Furnace Technology

The information in the following 3 paragraphs has been paraphrased from Minergy's Final Report on Sediment Melter Demonstration Project for WDNR, submitted in December 2001 (Minergy 2001).

Glass furnaces have been used for decades in industrial glass manufacturing. The process design of a glass furnace is focused on melting low-energy feedstock; that is, materials with low energy content, as measured in kilojoules (kj). Feedstock, consisting primarily of silica sand, melts in the furnace, and the molten product is cooled to form glass. Silica is one of the primary constituents of river sediment and, in this case, the GFT vitrifies the river sediment, with the expectation of destroying COCs and creating a useable aggregate as a final product. Minergy claims that other thermal destruction processes are too costly to be appropriate for use on river sediment, because the sediment has limited fuel value. Many other processes rely on the significant organic content (fuel content) of the feed material, but because limited energy is contained in sediment, large quantities of auxiliary fuel or electric power are needed. Minergy and WDNR have successfully completed two phases of a multiphase feasibility study (FS) to evaluate GFT as a remediation alternative. The first phase (Phase I) involved characterizing the mineral composition of river sediment to estimate glass quality, durability, and melting points. Data gathered during Phase I indicated that characteristics of river sediment are consistent throughout the river and are favorable for producing a quality glass product. Based on mineral composition, combustibility, moisture content, and costs to operate, Minergy claims that analysis of the sediment indicates vitrification technology is more appropriate than incineration for treatment of river sediment.

In Phase II, sediment from the Lower Fox River was test-melted in a crucible to determine glass characteristics and qualities of the vitrified sediment, both alone and when augmented with other materials (flux mixtures) to control melting temperatures and improve the physical properties of the glass aggregate product. Four different test "recipes" were included in the crucible melts, and the sediment was successfully melted into glass in all four tests. Data obtained during Phase II were used to develop (1) a proposed "recipe" for melting river sediment into glass aggregate, and (2) preliminary engineering designs for the pilot-scale facility proposed for Phase III. The preliminary engineering analysis indicated that it was not practical or cost-efficient to use an existing glass furnace for GFT testing. This analysis indicated that it would cost as much to retrofit an existing facility to specifications needed to melt the sediment as it would to build a pilot glass furnace to the same specifications. Project stakeholders also

discovered that most existing glass manufacturing facilities are too large to accommodate a limited duration test.

Results of the FS indicated that capital and operating costs of the GFT provide for an economically viable option for treating contaminated river sediment.

1.4.2 Minergy Corporation's Glass Furnace Technology

Minergy's intent with the GFT process was to treat dewatered sediment from the dredging site. The GFT process for the demonstration is shown in the diagram in Figure 1-1.

Sediment would be delivered in dewatered form, in the range of 45 to 55 percent solids (by weight). The first step of the process involves drying the sediment to about 10 percent moisture. Drying the sediment increases the overall efficiency of the process by limiting the amount of moisture in the melter, thereby reducing the physical volume of the feed and maintaining high processing temperatures. Several technologies were available for thermal drying. Ideally, gases from the drying step would be directed into the glass furnace or into another destruction device to control COC emissions.

In the planned GFT process, sediment passes from the drying system into the glass furnace. The glass furnace is a refractory-lined, rectangular melter. The refractory is a special type of brick that is resistant to chemical and physical abrasion, has a high melting point, and provides a high degree of insulating value to the process. The furnace, configured with oxygen and natural gas delivery systems with control and safety devices, attains internal temperatures of about 1,600 °C (2,900 °F). At this temperature, sediment melts and flows out of the furnace as molten glass.

The molten material is then quickly cooled in a water-quench system to form the glass aggregate product. Minergy claims that the glass aggregate can be stored and handled similarly to conventional quarried aggregates. Some off-site crushing and screening would be required to meet particle size specifications of certain aggregate markets.

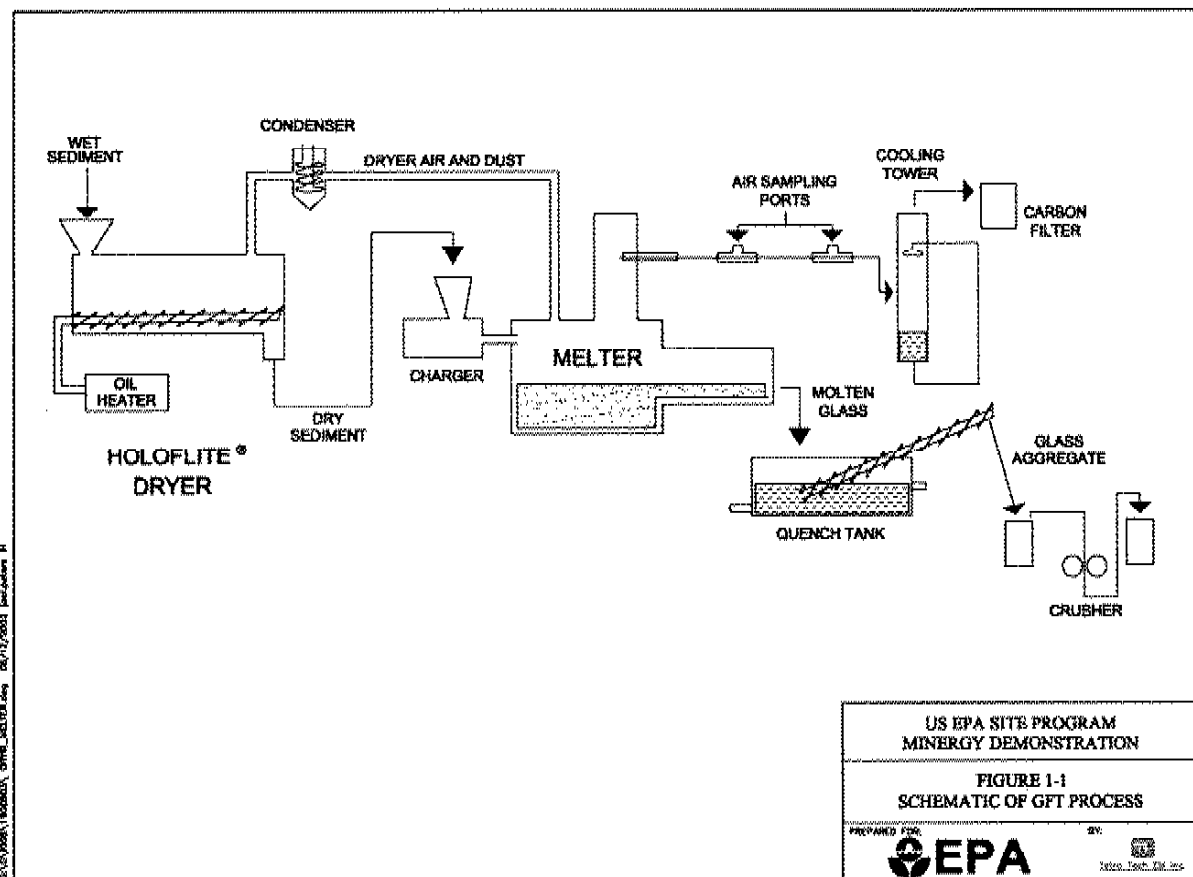


Figure 1-1 SCHEMATIC OF GFT PROCESS

Minergy expects that the high-temperature environment in the melter will completely destroy any organic compounds that may be present. In addition, trace metals in the sediment are expected to be stabilized in the glass aggregate product and are anticipated to be biologically and chemically inert. Minergy claims that off-gas treatment is simplified and energy efficiency is improved by the melter's use of purified oxygen, rather than atmospheric air, as the oxygen source. Minergy has made modifications to a standard glass furnace design, which have been incorporated to best suit this application, including the following:

- The height of the furnace was increased from typical designs to provide additional volume for destruction of organic vapors. The additional height increases the residence time that organic contaminants spend within the furnace.
- Use of a water quench system to quickly harden the molten glass and increase the inert characteristics of the final product. Glass melters typically use annealing or other slow-cooling processes to enhance glass clarity and other product qualities. These product qualities are not applicable to the manufacture of glass aggregate because of its intended final use as a construction product.
- Use of a "shallow" glass pool inside the melter. Glass melters typically have deeper pools of glass inside the melter, taking advantage of the low opacity of the glass being produced. Molten sediment is quite opaque, thereby reducing energy transfer by radiation.
- Use of refractory brick selected to resist corrosive and abrasive qualities of molten sediment.
- Use of flux materials selected to enhance properties of molten sediment material.

Minergy hopes to construct GFT treatment facilities in locations where sediment removal is chosen as a remedial approach, and to treat contaminated sediment as an alternative method to landfilling.

1.4.3 Site-specific Dryer Configuration

A dryer, determined by Minergy to be of suitable configuration, was located at the Hazen facility in Golden, Colorado. The Holoflite® dryer was a small, bench-scale unit with the capacity to process 14 pounds per hour (lb/hr) (6.4 kilograms per hour [kg/hr]) of dredged-and-dewatered (45 to 55 percent moisture) sediment. To produce an adequate feed material for introduction into the dryer, portions of the sediment were dried and mixed with dredged-and-dewatered sediment to reduce the stickiness of the material. Mixing dredged-and-dewatered sediment with dried sediment is a standard materials-handling practice that creates better flow characteristics.

The dryer itself consisted of a small metal box about 76 centimeters (30 inches) long that contained two hollow, oil-filled augers that turned slowly. The oil in the augers was heated to about 180 °C (360 °F), and the heat of the augers drove moisture from the sediment. The turning of the augers moved the sediment through the dryer to the end, where it fell into a flask. Water in the form of steam escaped from the dryer through a manifold in the top and was condensed and collected. The dryer reduced the moisture content of the sediment to less than 10 percent. Figure 1-2 shows the dryer used for the technology demonstration.

1.4.4 Site-specific Furnace Configuration

The pilot-scale glass furnace, or melter, was designed to simulate a full-scale production unit for generation of glass aggregate from sediment. To produce an adequate simulation, some assumptions were made regarding the full-scale melter, based on typical glass-manufacturing practices. Melter characteristics are presented in Table 1-1.

Figure 1-2 shows the melter as constructed for the demonstration. The pilot-scale melter area was 0.9 square meters (10 square feet), with a 2:1 aspect ratio, meaning that it was twice as long as it was wide. The melter was fired with oxygen and natural gas to use the best available control technology for nitrogen-related emissions and particulate matter. The melter had eight split-stream, oxygen-fuel (oxy-fuel) burners to approximate the eight burners used in a full-scale melter. The charger was a standard screw feeder used universally in glass furnaces. The screw feeder was chosen for its ability to tightly seal the hopper to the charger and the charger to the furnace. Tight seals minimized dust formation during introduction of the dried sediment into the melter. The charger was similar in size to those used in a full-scale unit, but was retrofit with a small screw barrel and flights for the pilot-scale melter.

The height of the glass processing area was slightly increased to provide additional volume for destruction of organic vapors. The flue was located in the front of the melter, which is not the traditional location for oxy-fuel furnaces. However, this configuration allowed any fine particulate matter that became entrained

TABLE 1-1
PILOT-SCALE MELTER CHARACTERISTICS
(supplied by Minergy)

Parameter	Measurement
Aspect Ratio (Length/Width)	2:1
Area	0.9 square meters (10 square feet)
Melting Rate	0.49 square meters per ton (5.4 square feet per ton)
Dwell Time	6 hours
Gas Usage	1.8 MM kj per hour (1.7 MM Btu per hour)
Oxygen Usage	1.1 cubic meters per hour (35 cubic feet per hour)
MM Btu/ton	22 MM kj per ton (21 MM Btu per ton)
Output	2.0 tons per day

Notes: Btu = British thermal unit
 kj = Kilojoule
 MM = Million Million

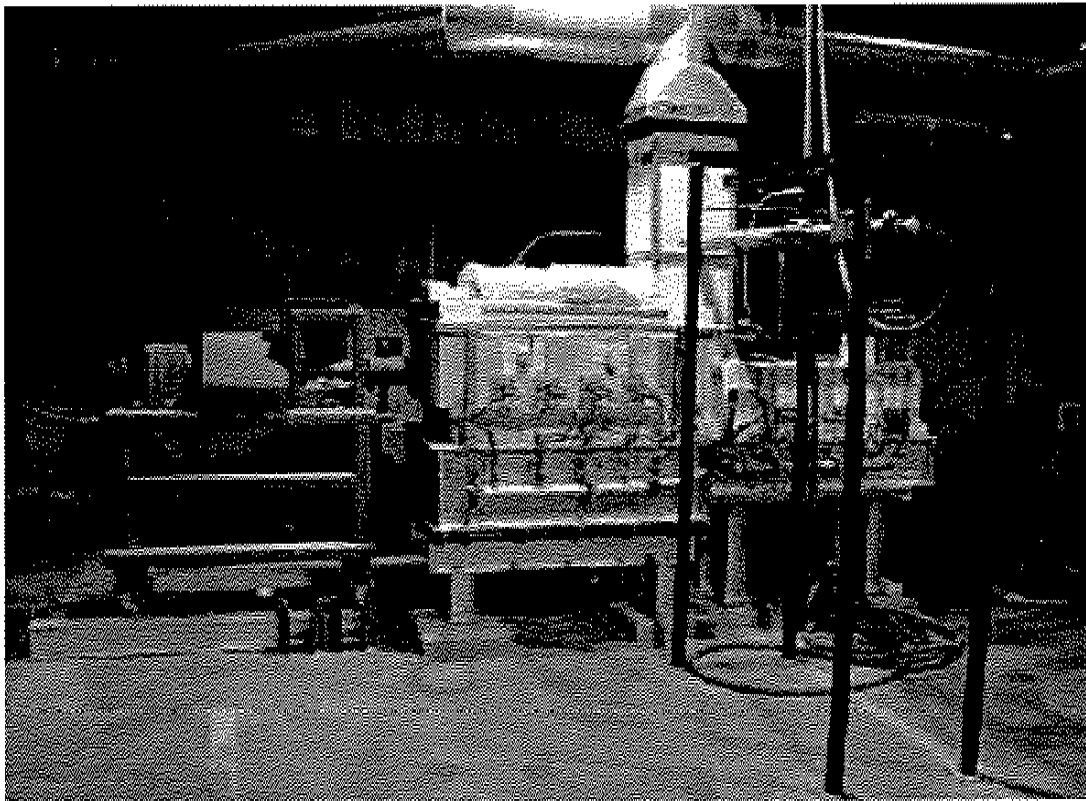


Figure 1-2 MELTER CONFIGURATION

in the exhaust gases to have the maximum residence time in the furnace, allowing these particulates to be melted or minimized.

The glass flowed under a skimmer block into a section of the glass furnace, called the forehearth. The forehearth was constructed in a conventional manner, with the glass outlet flowing to the water quench system. This method is used in other aggregate-making operations.

The pilot-scale melter was regulated by process controls. The controls used thermocouple signals to maintain a constant temperature and automatically adjust the gas and oxygen for each zone. Gas and oxygen delivered to the eight split-stream burners had several safety systems. The furnace is configured with oxygen and natural gas delivery systems with control and safety devices. If either natural gas or oxygen flow was lost, the system shut down that source. Each zone within the furnace was automatically regulated for gas and oxygen flows by a signal from the mass flow meter to a process control loop back to an automatic valve.

Refractory brick was selected by Minergy for the pilot-scale melter based on an evaluation of the abrasive qualities of the molten sediment and an analysis of thermal requirements. The analyses were conducted to ensure that the materials would not be used in temperatures beyond their specifications and to determine the total heat loss of the entire system.

1.5 KEY CONTACTS

Additional information on the GFT and the SITE Program can be obtained from the following sources:

- EPA SITE
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Email: tbaudhuin@minergy.com

Information on the SITE Program is available through the following on-line information clearinghouses:

- EPA's Reach It, developed by the Technology Innovations Office
<http://www.epareachit.org>
REACH - IT combines information from three databases: Vendor Information System for Innovative Treatment Technologies, Vendor Facts, and Innovative Treatment Technologies
- CLU-IN
<http://www.clu-in.org>
CLU-IN provides information about innovative treatment and site-characterization technologies, while acting as a forum for all waste remediation stakeholders

2.0 TECHNOLOGY APPLICATIONS ANALYSIS

This section assesses the general applicability of GFT to remediate PCB- and metal-contaminated sediment from Superfund and other hazardous waste sites. This assessment is based on results from the demonstration of the technology under the EPA SITE Program.

2.1 FEASIBILITY STUDY EVALUATION CRITERIA

This subsection assesses the GFT relative to the nine evaluation criteria used to conduct detailed analyses of remedial alternatives in Feasibility Studies (FSs) performed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This assessment of FS criteria assumes that the contaminated sediment will be transported to a fixed treatment facility and delivered in a dewatered state. Applicable or relevant and appropriate requirements (ARARs) regarding transportation, dewatering, and handling of pre-treatment waste are not considered to be part of this evaluation.

2.1.1 Overall Protection of Human Health and the Environment

This section addresses whether a technology provides adequate protection and describes how risks posed by each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

Minergy claims that the GFT provides both short- and long-term protection to human health and the environment by binding hazardous inorganic constituents into a noncrystalline, glass-like product. A risk evaluation to assess potential impact to human health and the environment was not performed as part of the SITE process.

In a full-scale operation, potential accidental releases during treatment could temporarily affect air quality in the vicinity of the treatment facility. Short-term exposure to workers may also occur during various materials-handling tasks.

2.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

This criterion addresses whether a remedy will meet all of the ARARs of federal and state environmental statutes. General and specific ARARs identified for the GFT are presented in Section 2.2. Compliance with chemical-, location-, and action-specific ARARs should be determined on a site-specific basis. Compliance with chemical-specific ARARs depends on the chemical constituents of the waste and the Treatment Efficiency (TE) of the glass melter system.

2.1.3 Short-term Effectiveness

Short-term effectiveness addresses the period of time needed to achieve protection of human health and the environment, as well as any adverse impacts that may be posed during the treatment period until clean-up goals are achieved.

Melting is a proven treatment technology for hazardous wastes contaminated with PCBs and inorganic constituents. Sediment melting transforms the physical state of contaminated sediment from assorted granular matrices to a glassy solid state. The Minergy process transforms sediment into a glass aggregate with minimal PCB and organic contaminants, and inorganic contaminants are incorporated into the glass matrix making them resistant to leaching. Exposure to contaminants during treatment should be minimal because of the design of the full-scale GFT, which includes automated handling and dust collection.

2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The anticipated performance of this treatment technology's potential for use at a Superfund site was assessed with respect to its ability to reduce the toxicity, mobility, or volume of waste. The GFT reduces the toxicity of the dredged-and-dewatered sediment by destroying organic contaminants and incorporating hazardous, inorganic constituents into a glass matrix, resistant to leaching. Test data from the Minergy SITE demonstration indicated that mercury and PCB concentrations in dredged sediment could be reduced to below laboratory detection in the final aggregate product. An almost three-fold volume reduction of sediment to glass aggregate was observed during the SITE demonstration.

2.1.5 Long-term Effectiveness

Long-term effectiveness refers to the ability of a technology to maintain reliable protection of human health and the environment over time. Based on Synthetic Precipitate Leaching Procedure (SPLP) and American Society of Testing and Materials (ASTM) water leach analyses performed on glass aggregate during the technology demonstration, it appears that any PCBs and metals present in the aggregate are resistant to leaching by aqueous solvents, rendering them biologically unavailable. Water leaching tests simulate natural weathering and can indicate whether the material will be resistant to leaching contaminants to groundwater.

PCBs and other organic contaminants present in the sediment are treated in the furnace atmosphere. In the GFT, metals are incorporated into the glass structure, thereby rendering metals resistant to leaching, based on the results of the leaching-test analyses. Crushed aggregate subjected to leaching analysis also indicated no contaminants will leach from the glass material over time.

2.1.6 Implementability

To consider the technical and administrative feasibility of a technology, including the availability of materials and services needed to implement a particular option, implementability of the technology is considered. GFT previously has been used to treat sludge from paper mills, power plants, and municipal wastewater processors. Only minor modifications to the handling systems and air pollution control system are required to use a similar system for treatment of PCB-contaminated sediments.

2.1.7 Costs

Estimated capital and operation and maintenance costs, as well as net present worth costs were considered for the SITE evaluation. For large-scale projects the GFT appears to be a cost-effective treatment alternative to landfilling. Section 3.0 of the report provides a detailed discussion of cost for this application.

2.1.8 State Acceptance

This criterion addresses technical or administrative issues and concerns that the support agency may have regarding the technology. This SITE demonstration project was performed cooperatively among EPA-ORD, WDNR, and EPA-GLNPO.

2.1.9 Community Acceptance

The SITE evaluation needs to address any issues or concerns the public may have regarding the GFT. Public acceptance of this technology should be positive for two reasons: (1) the technology presents minimal short- or long-term risks to the community, and (2) the material is permanently treated and not just relocated from one area (contaminated site) to another (landfill).

Contaminated sediment is a relatively common problem throughout the United States, with sediment removal and landfilling or solvent extraction generally being the most preferred remediation methods. The public is currently reluctant to accept placing PCB- and mercury-contaminated sediment in landfills. The public also has expressed a desire to explore remediation technologies that address the contaminant exposure pathway. The GFT can help in addressing the problem of disposal of contaminated dredge materials. Providing acceptable and cost-effective disposal of contaminated sediment would resolve the public's concern with contaminated sediment disposal and could significantly enhance clean-up actions.

2.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR THE GLASS FURNACE TECHNOLOGY

This subsection discusses federal and state environmental regulations that could be pertinent to operation of the GFT, including transport, treatment, storage, and disposal (TSD) of wastes and treatment residuals during a response action pursuant to CERCLA, as amended by the SARA. CERCLA provides for federal funding to respond to releases or potential releases of any hazardous substance into the environment, as well as to releases of pollutants or contaminants that may present an imminent or significant danger to public health and welfare or to the environment.

SARA includes a strong statutory preference for innovative technologies that provide long-term protection and directs EPA to:

- Use remedial alternatives that permanently and significantly reduce the volume, toxicity, or mobility of hazardous substances, pollutants, or contaminants.
- Select remedial actions that protect human health and the environment, are cost-effective, and involve permanent solutions and alternative treatment or resource recovery technologies to the maximum extent possible.
- Avoid off-site transport and disposal of untreated hazardous substances or contaminated materials when practicable treatment technologies exist.

In general, two types of response actions are possible under CERCLA: removal activities and remedial actions. The GFT would be part of a CERCLA remedial action.

Remedial actions are governed by SARA amendments to CERCLA. As stated above, these amendments promote remedies that permanently reduce the volume, toxicity, and mobility of hazardous substances, pollutants, or contaminants. The GFT is a toxicity reduction technology because it reduces PCBs and other contaminant concentrations in solid media.

On-site CERCLA remedial actions must comply with federal and more stringent state ARARs. CERCLA provides no ARARs itself; instead, CERCLA requires that remedial actions comply with substantive requirements of other environmental statutes. ARARs are determined on a site-by-site basis, considering the types of chemicals present (chemical-specific), actions taken and waste streams generated (action-specific), and location of the site in relation to sensitive environments (location-specific). Location-specific ARARs depend on site-specific conditions and are not addressed in this report.

This discussion addresses potential chemical- and action-specific ARARs. The GFT is designed to treat chemicals such as PCBs, metals, polynuclear aromatic hydrocarbons, VOCs, and metals. Waste streams generated by GFT relate to the material to be treated, dryer condensate, the desired properties of treated material, and personal protective equipment (PPE). The GFT is an *ex-situ* treatment technology, and generation and disposal of PCB waste, when exceeding 50 ppm, is regulated by TSCA and its implementing regulations at 40 CFR Part 761. If other contaminants also are present at a site, site wastes should be characterized to determine whether they meet the definition of hazardous wastes under RCRA. If so, RCRA requirements for management of hazardous wastes also will be ARARs for this technology.

Specific ARARs that may be applicable to the GFT are identified in Table 2-1.

2.2.1 Resource Conservation and Recovery Act

RCRA, an amendment to the Solid Waste Disposal Act, is the primary federal legislation governing hazardous waste activities. RCRA was enacted in 1976 to address safe disposal of the enormous volume of municipal and industrial solid waste generated annually. Subtitle C of RCRA contains requirements for generation and TSD of hazardous waste, most of which also are relevant and appropriate to CERCLA activities where hazardous wastes are managed. The Hazardous and Solid Waste Amendments of 1984 greatly expanded the scope and requirements of RCRA.

These regulations are applicable to the GFT only if RCRA defined hazardous wastes are treated or generated during the CERCLA action. Regulations that are likely to be listed as ARARs include the requirement to characterize waste for a hazardous waste generator (40 CFR Part 262.11), the requirement to determine if the hazardous waste is restricted from land disposal (40 CFR Part 268.7(a)), and either 40 CFR Part 262.34(a) for storage of waste on site up to 90 days prior to off-site shipment or 40 CFR Part 264.553 for storage of waste in a temporary unit for up to 1 year prior to disposal. Requirements for treatment and disposal units are considered to be ARARs for this process, because waste storage will be conducted on site. Waste generated by the GFT included treated material, dryer condensate, and used PPE. These materials would require analysis to determine requirements for disposal or discharge. If these wastes are determined to be hazardous according to RCRA (either because of a characteristic or a listing carried by the waste), all substantive RCRA requirements regarding management and disposal of hazardous waste must be addressed by remedial managers. Criteria for identifying characteristic hazardous wastes are included in Title 40 Code of Federal Regulations (CFR) Part 261, Subpart C. Listed wastes from specific and nonspecific industrial sources, off-specification products, spill clean-ups, and other industrial sources are itemized in 40 CFR Part 261, Subpart D. The technology could be used on sites where lead, cadmium, chromium, mercury, or other metals are present and could, depending on concentrations, be characteristic hazardous wastes. PPE and clean-up wastes from a PCB-contaminated site (if greater than 50 ppm) may not be disposed of in an ordinary landfill. It must be disposed of in a TSCA chemical waste landfill or a TSCA incinerator. Because this is a fixed treatment facility that will have waste delivered to the site, clean-up waste should not be an issue. PPE used at the treatment facility will require special disposal.

Listed hazardous wastes (40 CFR Part 261, Subpart D) remain listed wastes, regardless of the treatment they may undergo and final contamination levels in the resulting effluent streams and residues. This regulation implies that, even after remediation, treated wastes are still classified as hazardous if the

pre-treatment material was a listed waste. Under the contained-in policy, listed wastes contained in other materials that are managed as waste require that those materials be managed as listed wastes. Material can be de-listed in many cases, depending on the attributes of the treated material.

For generation of any hazardous waste, the responsible party must obtain an EPA identification number. Other applicable RCRA requirements may include a Uniform Hazardous Waste Manifest (if the waste is transported), restrictions on placing the waste in land disposal units, time limits on accumulating waste, and permits for storing the waste.

RCRA corrective action regulations regarding corrective action management units (CAMUs) and temporary units may be ARARs for CERCLA action involving RCRA hazardous waste. The CAMU rule allows for disposal of remediation wastes without triggering land disposal restrictions and minimum technology requirements. The temporary units rule allows treatment or tanks without triggering RCRA tank regulations.

2.2.2 Toxic Substances Control Act

TSCA grants EPA authority to prohibit or control the manufacture, import, processing, use, and disposal of any chemical substance that presents an unreasonable risk of injury to human health or the environment. Regulations promulgated under TSCA may be found at 40 CFR Part 761.

Most of the PCB contamination addressed by this technology will be in waste that contains more than 50 ppm PCB contamination and is defined as “PCB remediation waste” under 40 CFR Part 761.3, and its remediation and disposal will be regulated by 40 CFR Part 761.61. Three options in 761.61 to dispose of PCB remediation waste, and substantive clean-up levels are provided in 761.61(a), the “self-implementing” clean-up option. Requirements in Part 761.61(b) are for a “performance-based” option for disposing of PCB remediation waste and give performance specifications for certain disposal technologies such as incineration and placement in a chemical landfill. The final option is for a “risk-based approval” and is found in 40 CFR Part 761.61(c). This option contains no substantive requirements or ARARs, but allows EPA Regional Directors to approve remedial actions for PCBs through a site-specific, risk-based decision.

Minergy’s GFT demonstration was considered to be exempt from TSCA because PCB concentrations in the sediment were consistently below 50 ppm. The full-scale implementation will likely treat sediment

with PCB concentrations greater than 50 ppm, and approval for treatment of that sediment would be subject to EPA approval.

2.2.3 Clean Air Act

The CAA and its 1990 amendments establish primary and secondary ambient air quality standards for protection of public health and emission limitations on certain hazardous air pollutants.

CAA permitting requirements are administered by each state as part of State Implementation Plans developed to bring each state into compliance with National Ambient Air Quality Standards (NAAQS). Ambient air quality standards for specific pollutants apply to the operation of the GFT system, because the technology ultimately results in an emission from a point source to ambient air. Allowable emission limits for the operation of a GFT system will be established on a case-by-case basis, depending on the type of waste treated and whether the site is in a NAAQS attainment area. Allowable emissions limits may be set for specific hazardous air pollutants, particulate matter, hydrogen chloride, or other pollutants. An air pollution control system will likely be required to control the discharge of emissions to the ambient air.

2.2.4 Occupational Safety and Health Administration

Several requirements must be addressed, although they are not ARARs. CERCLA remedial actions and RCRA corrective actions must be performed in accordance with the Occupational Safety and Health Administration (OSHA) requirements detailed in 29 CFR Parts 1900 through 1926, particularly 29 CFR Part 1910.120, which provides for the health and safety of workers at hazardous waste sites. On-site construction activities at Superfund or RCRA corrective action sites must be conducted in accordance with 29 CFR Part 1926, which describes safety and health regulations for construction sites. State OSHA requirements, which may be significantly stricter than federal standards, also must be met. All technicians operating the GFT system are required to have completed an OSHA training course and must be familiar with all OSHA requirements relevant to hazardous waste sites. Noise levels are an OSHA concern, but GFT noise levels are not expected to be high. Therefore, anticipated noise levels are not expected to adversely affect the community.

2.2.5 Department of Transportation Regulations

Once dredged sediment is dewatered, it may need to be transported, depending on the siting of the treatment facility. Minergy's intent is to site the treatment facility as close to dredging-and-dewatering operations as possible. Off-site shipment of hazardous materials is subject to Department of Transportation (DOT) requirements for packaging and placarding. Additionally, if the treated material was generated from a RCRA-defined hazardous waste, the material would be subject to DOT regulations in 49 CFR Parts 172 and 173.

2.2.6 Comprehensive Environmental Response, Compensation, and Liability Act Off-Site Rule

The CERCLA Off-site Rule requires that wastes taken from a CERCLA site for off-site disposal must be transported to permitted waste disposal facilities. Each EPA Region has a coordinator for assistance in identifying disposal facilities in the region that are in compliance with their appropriate permits and that are approved to receive waste from CERCLA sites.

CERCLA covers specific environmental regulations pertinent to demonstration and operation of the GFT, including transport and treatment, storage, and disposal of wastes and treatment residuals. CERCLA, as amended by SARA, requires consideration of ARARs. CERCLA issues, although not true ARARs, also are considered.

2.3 OPERABILITY OF THE TECHNOLOGY

A schematic of the GFT process is shown as Figure 1-1. According to Minergy, the first step in the glass aggregate recycling process is to receive dewatered sediment at the full-scale treatment facility. It is assumed that sediment will be dewatered in the vicinity of dredging operations, unless a pipeline is used to transfer sediment slurry to the treatment facility. Within the treatment facility, the sediment will be conveyed to a drying system, where the solids are dried to approximately 10 percent moisture. The dryer will be vented to the melter furnace to ensure that contaminants potentially released in dust during the drying process are treated.

The GFT is designed so that dried sediment will be conveyed from the dryer system to the melter, at which point sediment melts and flows out of the furnace as molten glass. High temperatures in the

furnace are expected to remove or destroy organic compounds contained in the sediment, including PCBs. In addition, the melting process is expected to permanently stabilize the metals within the glass.

The molten glass flows into a water quench bath, where it cools quickly and forms the glass aggregate product. In this form, the glass aggregate product can be stored and handled similarly to conventional quarried aggregates. Some crushing and screening can be done, as required to meet the size requirements of a particular application. Potential markets for the glass aggregate product include floor tiles, abrasives, roofing shingles, asphalt and chip seal aggregates, and decorative landscaping.

2.4 KEY FEATURES OF GLASS FURNACE TECHNOLOGY

This section describes the key features of the GFT process, which may separate it from other remedial technologies. These features may be unique to the Minergy GFT.

2.4.1 Contaminant Reduction

One of the primary objectives of the SITE evaluation was to assess the efficiency of the GFT in removing or destroying PCB concentrations in the sediment. This objective was accomplished by sampling the sediment before treatment, the glass aggregate, the furnace flue gas, the quench water, and the cooling tower discharge water. The PCB concentration in the dewatered sediment averaged 28.8 ppm based on a geometric mean. The geometric mean of the PCB concentrations in the glass aggregate was 1.4×10^{-4} ppm.

The treatment efficiency (TE) was calculated using the geometric mean of the total PCB concentrations from each sampled media. The TE calculation is further discussed in Section 4.3.3.1.

2.4.2 Mass Reduction

The SITE demonstration began in June 2001, but the melter run was interrupted because of a failure of the furnace refractory brick, allowing molten glass to leak. About 4,900 kg (11,000 lbs) of river sediment had been processed at the time the system shut down. After the furnace was repaired, the demonstration was restarted in August 2001, during which steady operating conditions were achieved and maintained throughout the demonstration. About 7,500 kg (17,000 lbs) of sediment were processed during the August demonstration.

A total of 12,400 kg (27,000 lbs) of sediment was treated during the two demonstrations, resulting in the generation of about 4,900 kg (11,000 lbs) of glass aggregate. A mass reduction of 2.5 to 1 was observed during the demonstrations, based on information obtained from Minergy.

2.4.3 Glass Aggregate Qualities

Minergy claims that the glass aggregate product has qualities that support its value in the marketplace. It does not leach PCBs or metals and has desired physical properties, such as high particle density. These properties qualify the product for use as construction fill, floor-tile component, roofing-shingle granules, or an additive to concrete.

2.4.4 Full-scale Design

Minergy has designed a full-scale GFT system to support large river-sediment dredging operations. The treatment facility is expected to be located nearby dredging and dewatering operations to minimize transportation costs. The design incorporates mixing and drying, flux addition and mixing, and melting. The design incorporates several distinctive elements, such as, heat exchangers to capture lost heat and run the dryers, venting to reduce particulates in the air stream, and closed conveyors to move sediment without creating dust. The full-scale GFT is designed to melt 600 tons per day of dewatered sediment and produce 250 tons per day of glass aggregate. A unit cost study was performed by Minergy that evaluated costs to build and run full-scale treatment facilities of 250, 500, and 750 tons of glass per day.

2.4.5 Clean Air Emissions

Glass furnaces use oxygen-fuel burners, combining natural gas and oxygen to heat the furnace. The burners raise the internal temperature of the furnace to 1,600 °C (2,900 °F). The use of oxygen instead of atmospheric air keeps nitrogen oxide emissions low and results in a cleaner burning operation. PCB emissions from the pilot-scale melter were low (geometric mean of the samples collected was 3.5×10^{-6} ppm).

2.4.6 Costs

Unit costs for the full-scale implementation of Minergy's GFT are detailed in Section 3.0. The cost to treat dewatered sediment with the GFT was estimated at \$38.74 per ton. These costs are comparable to landfilling costs. Because it appears that contaminant concentrations in the treated glass aggregate have been permanently removed, or are resistant to leaching, the future liability associated with landfilling the glass product seems to be much lower than that associated with landfilling the dewatered sediment.

The glass produced by the GFT may have some economic value that could offset some of the implementation or disposal costs. Additionally, reuse of the treated material will minimize the need to landfill the glass aggregate, reducing the need for landfill space.

2.5 APPLICABLE WASTES

The GFT process produces a glass aggregate product from contaminated sediment. There are three sources of process wastewater: quench-tank water, condensate from the dryer exhaust, and blowdown from the exhaust cooling tower. The condensate from the dryer exhaust and blowdown from the exhaust cooling tower will likely require permitting and treatment prior to disposal.

2.6 AVAILABILITY AND TRANSPORTABILITY OF EQUIPMENT

The GFT process for handling contaminated soils was initially developed by Minergy to process wastewater sludge into glass aggregate that could be sold as a commercial product. The melter is modified from a standard glass furnace. Other components, such as the indirect heat disc or paddle dryers and packed cooling towers, are used in other industries and can be modified to fit the requirements of the GFT process. Based on the amount of on-site assembly required, facility construction would be expected to take about 9 to 12 months. Minergy states that, for a project of suitable size, design work could begin immediately. The size of the equipment limits the potential for a transportable unit. Because the equipment is housed within a building, the facility could be constructed anywhere that space and permitting would allow.

2.7 MATERIALS-HANDLING REQUIREMENTS

The GFT process is most efficient when feed materials contain less than 10 percent water and metal particles, such as nuts or bolts, etc., have been minimized. Mixing is necessary to get the material to feed through the dryers, where the moisture content will be reduced to about 10 percent. Waste feed may require the addition of a fluxing agent to control melting temperatures and improve the physical properties of the glass aggregate product. For the SITE demonstration, waste feed pretreatment consisted of reducing the particle size, removing excess metal, drying, and blending with 5 percent sodium sulfate by weight. Large pieces of material, iron in particular, are expected to be found in the dredged sediment. These pieces will be removed before pumping the sediment slurry or mixing the dewatered sediment with dried sediment. After processing through the full-scale GFT, the glass aggregate product will be withdrawn from the water quench by a set of screws, dewatered, and transported to a storage pile. The aggregate will then be removed from the site for sale or disposal.

2.8 LIMITATIONS OF THE TECHNOLOGY

The GFT system has several limitations. Since the treatment facility is not transportable, material must be delivered to the facility for treatment. The material must be dewatered, either mechanically or passively, to about 50 percent moisture prior to drying. Additional indoor storage of feed material will be required in cold climates to keep material in a non-frozen state.

Although the cost analyses performed in this ITER are based on a project that would treat 1-million-tons of sediment, Minergy claims that melters could be scaled to accommodate sediment projects of most sizes. This could include sediment from multiple sites that can be delivered to a centrally-located treatment facility.

TABLE 2-1
POTENTIAL FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR
THE GLASS FURNACE TECHNOLOGY

Process Activity	ARAR	Description	Basis	Requirements
Sediment Characterization	RCRA 40 CFR Part 267 or state equivalent	Identify and characterize sediment to be treated.	A RCRA requirement must be met before managing and handling waste.	Chemical and physical analyses must be performed.
Notification	TSCA 40 CFR Part 761	Mandate notification to EPA of PCB waste activity.	Any activity associated with PCB waste has notification requirements.	Notify EPA with Form 7710-53.
Transportation for Off-site Treatment	RCRA 40 CFR Part 262 or state equivalent	Mandate manifest requirements, packaging, and labeling prior to transporting.	Waste may require manifesting and managing as a hazardous waste.	An ID number must be obtained from the EPA.
	RCRA 40 CFR Part 261 or state equivalent	Set transportation standards.	Waste may need permits for transportation as a hazardous waste.	A licensed hazardous waste transporter must be used.
Storage of Sediment Prior to Processing	RCRA 40 CFR Part 264 or state equivalent	Apply standards for storage of hazardous waste.	The sediment will be stored on site prior to treatment.	If separate storage building is not used, material must be placed on and covered with plastic to minimize fugitive air emissions volatilization and water infiltration.
	TSCA - 40 CFR Part 761	Apply standards for storage of PCB waste.	The sediment will be stored on site prior to treatment.	Storage is limited to 1 year, unless written notification is granted from EPA. The storage facility must be constructed to control runoff/runoff and must be approved by EPA.
Waste Processing - Smelting, Melting, and Refining Furnace	RCRA 40 CFR Parts 264, 265, 266 (Boilers and Industrial Furnaces Rule in Subpart H and Part 270)	Apply standards for the melting of hazardous waste at permitted and interim status facilities.	Processing of hazardous waste must be conducted in a manner that meets RCRA operating and monitoring requirements.	Equipment must be maintained daily. Air emissions must be characterized by continuous emissions monitoring. Equipment decontamination is required upon completion.

TABLE 2-1 (continued)
POTENTIAL FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR
THE GLASS FURNACE TECHNOLOGY

Process Activity	ARAR	Description	Basis	Requirements
Storage After Processing	RCRA 40 CFR Part 264 or state equivalent	Apply standards for the storage of hazardous waste.	If vitrified product is derived from treatment of a RCRA-listed waste, requirements for storage of hazardous waste in containers will apply.	The vitrified product must be stored in containers that are well-maintained and stored in an area constructed to control runoff.
Disposal	RCRA 40 CFR Part 264 or state equivalent	Apply standards for landfilling hazardous waste.	By-products derived from treatment of hazardous waste may need to be managed as hazardous waste.	Wastes must be disposed of at a RCRA-permitted facility, or EPA approval for other disposal action must be obtained.
Disposal	RCRA 40 CFR Part 268 or state equivalent	Apply standards that restrict placement of certain hazardous wastes on the ground.	The waste may be subject to federal Landfill Disposal Regulations (LDRs).	Waste must be characterized to determine if LDRs apply; treated waste must be tested and results compared to the standard.
	TSCA 40 CFR Part 761 or state equivalent	Apply disposal options for PC3 remediation waste.	PC3 waste is subject to federal requirements regarding disposal.	Apply in writing to the EPA regional administrator for risk-based disposal approval.
Post-treatment Transportation	RCRA 40 CFR Part 262 or state equivalent	Apply manifest requirements and packaging and labeling requirements prior to transporting.	By-products may need to be manifested and managed as hazardous waste if they are derived from hazardous waste.	An ID number must be obtained from EPA.
	RCRA 40 CFR Part 263 or state equivalent	Apply transportation standards.	By-products may need to be transported as a hazardous waste if they are derived from hazardous waste.	An EPA licensed transporter must be used.
Flue Gas Emissions	CAA or equivalent State Implementation Plan	Control air emissions that may impact air quality standards.	An off-gas treatment system is part of the glass furnace technology system design.	Treatment of contaminated air must adequately remove contaminants so that air quality is not impacted.

TABLE 2-1 (continued)
POTENTIAL FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR
THE GLASS FURNACE TECHNOLOGY

Process Activity	ARAR	Description	Basis	Requirements
Worker Safety	OSHA 29 CFR Parts 1900 through 1926; or state OSHA requirements	Apply worker health and safety standards.	Comprehensive Environmental Response, Compensation, and Liability Act remedial actions and RCRA corrective actions must follow requirements for the health and safety of on-site workers.	Workers must have completed and maintained OSHA training and medical monitoring; use of appropriate personal protective equipment is required.

Notes: ARAR - Applicable or relevant and appropriate requirements
CAA - Clean Air Act
CFR - Code of Federal Regulations
EPA - U.S. Environmental Protection Agency
ID - identification
LDR - landfill disposal restrictions
OSHA - Occupational Safety and Health Administration
PCB - Polychlorinated biphenyl
RCRA - Resource Conservation and Recovery Act
TSCA - Toxic Substance Control Act

3.0 ECONOMIC ANALYSIS

Cost data were compiled during the SITE demonstration at the Minergy facility in Winneconne, Wisconsin, as well as from information obtained from Minergy. Costs have been placed in 12 categories applicable to typical clean-up activities at Superfund and RCRA sites (Evans 1990). Costs are considered to be order-of-magnitude estimates, with an expected accuracy to within 50 percent above and 30 percent below actual costs.

This section describes costs associated with using GFT to treat contaminated sediment and presents the conclusions of the economic analysis.

3.1 INTRODUCTION TO ECONOMIC ANALYSIS

PCBs are identified in river and stream sediments at various locations throughout the United States. Various remedial options are under consideration for treating these and other contaminated sediment. This economic analysis presents costs associated with vitrifying contaminated river sediment at high temperatures, removing, destroying, or binding PCBs and any metals in the glass aggregate product produced. Several cost scenarios were reviewed, including varying the size and annual operational days for the system. The scenario used for this analysis consisted of one sediment melter rated at about 600 tons of sediment per day combined with three dryers rated at an input capacity of 200 dredged-and-dewatered tons per day per dryer. Sediment storage was included to allow year-long operation in all climates.

Important assumptions regarding operating conditions and task responsibilities that could affect the cost estimate results are presented in the following sections.

3.2 BASIS OF ECONOMIC ANALYSIS

Costs for the GFT have not previously been applied to full-scale remediation projects for sediments. Historical project construction data and data for relatively standard construction practices are available for other components, such as sediment removal and disposal, but such data are not available for the GFT.

A conventional present worth (PW) approach was used for this cost analysis. This approach is universal, in that it provides procedures for computing the PW of any cost to be considered. In the conventional approach, each cost is escalated and discounted in separate steps, as necessary to determine its PW.

Costs incurred over the lifetime of a project are classified into four types of cost with respect to frequency of occurrence:

1. One-time costs are incurred only once over the life of the project. These costs include those for initial investment, startup, and some alterations or modifications.
2. Continuous costs are incurred periodically throughout a given year. Examples are energy costs, operational labor costs, scheduled maintenance costs, and sampling costs.
3. Cyclical costs are incurred several times over the life of the project, but less than annual costs. Some of these costs include some alterations, repair, or replacement of equipment.
4. Annually recurring costs are incurred once each year over the life of the project. These costs would include annual monitoring and permitting.

The cost elements in the following section were classified into one of these four categories. The cost of all items was assumed to escalate at a rate less than, or equal to, the general inflation rate. Therefore, the differential escalation rate is zero. The discount rate, based on the Office of Management and Budget (OMB) Circular A-94 and a project life expectancy of 15 years, was calculated at 3.3 percent (OMB 1977). Several additional assumptions were made in this cost estimate, based on an understanding of process requirements, equipment design, and information from the demonstration project performed. Assumptions are identified as they relate to each section of the process.

3.3 COST ELEMENTS

The costs directly attributable to the treatment component are discussed below in terms of the cost elements generally used by the SITE Program for evaluating treatment costs based on field tests for treatment technologies. The relative importance of each element in selecting various treatment technologies depends on unit operations involved in the process, the importance of chemical additives for the process, energy requirements and costs, and project-specific factors. The cost elements are the following:

- **Site Preparation Costs** - This element includes site design and layout, surveys and site logistics, legal searches, access rights and roads, preparation of support facilities, and utility connections. Where the site is used for more than just the treatment technology (for example, pretreatment or disposal of residues), site preparation costs may be partially included in the costs for other components.

- **Permitting and Regulatory Requirements** - This element includes permits required by RCRA, TSCA, and CAA, system monitoring requirements as may be required by state regulations, and development of monitoring and analytical protocols to comply with regulatory requirements.
- **Capital Equipment** - Major equipment items, process equipment, and residual materials handling equipment are included in this element. The annualized equipment cost is based on the life of the equipment, the salvage value, and the annual interest rate.
- **Startup Costs** - Costs associated with operator training, system startup, and ensuring the proper functioning of the system.
- **Labor Costs** - Labor charges for operational, supervisory, administrative, professional, technical, maintenance, and clerical personnel supporting the treatment processes must be estimated for this element.
- **Consumables and Supplies** - The raw materials and supplies required to process the material are included in this element.
- **Utilities** - Fuel, oxygen, and electricity required to process the material are included in this element.
- **Residue Treatment and Disposal Costs** - Treatment systems may generate one or more residues (for example, water, oil, solids, sludges, air, or gas) that require further treatment before discharge or disposal. This element may also include filters or carbon treatment to control air emissions.
- **Transportation Costs** - Some transportation of dewatered sediment may be necessary if the treatment facility is not located in proximity to dredging and dewatering operations. Costs do not include transportation of glass aggregate to an off-site location.
- **Monitoring and Analytical Costs** - Field and laboratory costs for monitoring conditions of the treatment process and the quality of residues are included in this element.
- **Facility Modification, Repair, and Replacement Costs** - This element includes design adjustments, facility modifications, scheduled maintenance, and equipment replacement. Maintenance labor costs are assumed to be part of the operational labor costs.
- **Site Demobilization Costs** - Costs for demobilizing the GFT include equipment demolition and general clean-up.

The 12 cost factors examined as they apply to GFT, along with the assumptions employed, are described in the following paragraphs and are shown in Table 3-2.

3.3.1 Site Preparation

The amount of preliminary site preparation required will depend on the site's location, suitability for development, and proximity to dredging operations. Site preparation components include site design and layout, surveys and site logistics, legal searches, access rights and roads, preparation for support and decontamination facilities, utility connections, fixed auxiliary buildings, and soil stockpiling. No costs for geotechnical evaluation of the treatment site are included. It is also assumed that the facility will be constructed in an area zoned industrial. Because of the variability in property value and utility availability throughout the country, costs associated with lease or purchase of property are not included. This cost analysis begins with the sediment dewatered to a moisture content of 50 percent; therefore, excavation or dredging, mobilization, and dewatering costs are not included. It is assumed that metals removal during full-scale implementation will occur prior to dewatering; additional metals removal is not included as part of this cost estimate.

Once dewatered, the material will be moved by front-end loader to the drying equipment. Costs to move the material to the treatment unit include costs for operating heavy equipment, labor charges, and equipment fuel costs. These costs are broken down in the labor, capital equipments and consumables sections; therefore, no site preparation costs are included in this cost analysis.

3.3.2 Permitting and Regulatory Costs

Permitting and regulatory costs will vary, depending on location of the treatment facility. ARARs include federal standards, as well as more stringent standards under state or local jurisdiction.

All of the exhaust cooling systems in the GFT use non-contact heat exchangers to prevent contamination of cooling water. The exhaust is designed to allow for minimal particulate within the air stream. Costs for initial permitting of this facility are estimated at about \$150,000. Sampling of the air stream and wastewater for permitting purposes is estimated to be \$10,000 per year, which includes professional services, analytical services, and regulatory fees. Initial permitting is a one-time cost, and sampling and permit update costs are an annually recurring cost. Using a discount rate of 3.3 percent, the net PW of the permitting and regulatory costs is \$252,400. Based on the estimated project life of 15 years and facility throughput of 210,000 tons per year, the permitting and regulatory cost is estimated to be \$0.08 per ton.

3.3.3 Capital Equipment

Equipment costs associated with the GFT include the sediment storage building, melter building, sediment mixers, sediment dryer, sediment-handling system, glass melter, oxygen-generating plant, and off-gas treatment system. Capital costs are based on information supplied by Minergy. Costs to construct the melter, associated equipment, and buildings, as detailed in Table 3.1, are estimated at \$36,387,736. Based on an estimated operating life of 15 years and contaminated sediment volume of 210,000 tons per year, the estimated capital equipment cost is \$11.55 per ton.

TABLE 3-1
PROJECTED CAPITAL COSTS - SEDIMENT MELTING PLANT

Item	Cost
Melter (delivered and installed)	\$ 7,511,976.00
Dryer (3@ \$862,835)	\$ 2,588,505.00
Materials-Handling System	\$ 3,019,923.00
Dryer Off-gas System	\$ 394,515.00
Thermal Oil System	\$ 995,579.00
Air Quality Control System	\$ 468,931.00
Oxy-fuel System	\$ 845,081.00
Utilities Equipment	\$ 488,383.00
Mechanical Contractor	\$ 7,886,711.00
Electrical Contractor	\$ 2,113,548.00
Main Building	\$ 2,634,900.00
Engineering	\$ 5,274,684.00
Front-end loader	\$ 365,000.00
Sediment Storage Building	\$ 1,800,000.00
TOTAL	\$ 36,387,736.00

3.3.4 Startup Costs

Startup costs include training of operators and workers on equipment use and health and safety procedures, initial system testing, and system shakedown. Startup costs are estimated at \$764,000. Based on an estimated operating life of 15 years and contaminated sediment volume of 210,000 tons per year, the estimated capital equipment cost is \$0.24 per ton.

3.3.5 Labor Costs

The facility is assumed to operate 24 hours per day, 350 days per year. Based on operations at similar facilities and observations during the SITE demonstration, a four-person crew per shift should be adequate for safe operation of the facility. The crew would consist of a shift supervisor, two equipment operators, and a laborer. Assuming three shifts consisting of four crews, labor charges for operational, supervisory, administrative, professional, technical, maintenance, and clerical personnel supporting the treatment processes are estimated at \$2,382,000 per year. The net PW of labor costs over the 15-year life is estimated at \$27,829,000. Based on the throughput of 210,000 tons per year, estimated labor costs are \$8.83 per ton.

3.3.6 Consumables and Supplies

Minergy has estimated the consumables and supplies to cost \$241,900 per year. In addition, the system uses a lime flux rate of approximately 15 percent. With a lime flux cost of \$25 per ton, flux costs are estimated at \$447,000 per year. The net present worth of consumables and supplies over the 15-year life is estimated at \$8,048,400. Based on the throughput of 210,000 tons per year, estimated consumables costs are \$2.56 per ton.

3.3.7 Utilities

The facility is expected to use approximately 1.9 million Btu of gas per ton of treated sediment and 115 kilowatt-hours of electricity per ton of treated sediment. Based on estimates of gas delivery at \$3.25/million btu and an electricity rate of 4.5 cents per kilowatt hour, utility costs are estimated at \$2,403,000 per year. The PW of operational costs over the 15-year life is estimated at \$28,074,000, or \$8.91 per ton.

3.3.8 Residue Treatment and Disposal Costs

The three sources of process water for the operation are condensate from the dryer, blowdown from the packed tower on the melter exhaust, and cooling tower blowdown. The condensate from the dryer may have high total suspended solids (TSS), as well as potential PCB contamination, attached to sediment particles. This water will require treatment prior to disposal. The packed tower blowdown will have high concentrations of TSS and high chemical oxygen demand. The cooling water blowdown is a non-contact cooling water and therefore would not require treatment prior to disposal.

The volume of process water requiring treatment is estimated at 63 gallons per minute, for an annual estimated volume of 31.7 million gallons. This process water will be routed through the wastewater treatment facility processing the dredged sediment. If the sediment is delivered to the melter in a dewatered state, no treatment facility for the dredged water will be available. Therefore, it is assumed that this water would be sent to a municipal treatment facility. Assuming a municipal charge of \$1.50 per 1,000 gallons, the annual costs for treating the process water is estimated to be \$47,600, or over the life of the facility, an estimated cost of \$0.18 per ton.

3.3.9 Transportation Costs

It is assumed that for the full-scale operation of the GFT, the facility will be located next to the dewatering operation and that no transportation of the dewatered sediment will be necessary before staging the sediment for processing through the GFT.

3.3.10 Monitoring and Analytical Costs

Field and laboratory costs for monitoring conditions of the treatment process and the quality of residues are included in this element. Incoming sediment will be sampled at a rate of one sample per 300 tons of sediment. Treated material will require initial analysis to prove treatment effectiveness and periodically throughout the treatment process. Monitoring and analytical costs are estimated at \$300,000 per year. Based on the 15-year life and throughput of 210,000 tons per year, estimated monitoring and analytical costs are \$1.11 per ton. These monitoring and analytical costs are based on TSCA regulatory requirements as the most stringent requirements. In some cases less stringent monitoring may be possible.

3.3.11 Facility Modification, Repair, and Replacement Costs

Maintenance labor is included as a part of operational labor costs. Minergy has estimated operations, replacement, and repair costs to be \$1,370,455 per year. Modification costs are site-specific and vary, based on weather issues, regulatory changes, or operational observations; therefore, modification costs are not included in this cost estimate. Based on the 15-year life and throughput of 210,000 tons per year, estimated operations and maintenance costs are \$5.08 per ton.

3.3.12 Site Demobilization Costs

It is assumed that the site used for the treatment process will be purchased or leased by Minergy or the responsible party. Site restoration requirements will vary, depending on the future use of the site, and therefore are not included in this analysis. Costs to demobilize equipment at the end of 15 years are estimated at \$1,000,000. Based on the above-identified discount rates and sediment throughputs, the estimated cost for demobilization of the equipment is estimated at \$0.20 per ton. Based on the above costs, the total cost to treat dredged-and-dewatered sediment with the GFT was estimated at \$38.74 per ton.

3.4 BENEFICIAL REUSE

The GFT glass aggregate product passes the ASTM water leachate test. Contaminants contained in the river sediment appear to be stabilized within the glass matrix of the product and, according to data obtained during the SITE demonstration, are not available to leach into the environment. Leaching tests were conducted to evaluate the primary objective associated with beneficial reuse of the glass aggregate, the methods for which are discussed in Section 4.3.2.7. Results of the leaching tests and a comparison to beneficial reuse criteria is presented in Section 4.3.3.1. Further, the GFT glass aggregate product can be stored like any quarried aggregate.

Glass aggregate product can meet industrial requirements for the manufacture of the following products:

- Ceramic floor tile
- Abrasives
- Concrete additives
- Asphalt paving and chip seal
- Roofing shingle granules

Depending on use, markets may require additional manipulation of material, and those costs are not included in this analysis. Glass aggregate product sales will vary by demand, and credits are also not included as part of this cost analysis.

3.5 SUMMARY OF ECONOMIC ANALYSIS

This section summarizes the costs for the GFT process. Costs were based on information from the pilot study, data supplied by Minergy, and information collected from other industry sources. Estimated costs identified within this section were based on the assumptions previously identified in Sections 3.2 and 3.3. The facility identified within this section is estimated to treat about 600 tons of dredged-and-dewatered sediment per day, which produces about 250 tons of glass per day. It is estimated that the facility would operate 350 days per year for 15 years, which works out to approximately 3.2 million tons of treated sediment.

The net present value (NPV) of the facility was determined for all components. To compute NPV, it is necessary to discount future benefits and costs, which reflect the time value of money. The discount rate used for this estimate was 3.3 percent, based on current OMB guidelines.

The NPV of the facility described in this document was estimated at \$122,041,000. The estimated cost per ton to treat the sediments is \$38.74 per ton.

Costs identified in Section 3.3 are summarized in Table 3-2.

TABLE 3-2
SUMMARY OF COSTS FOR MINERGY GLASS FURNACE TECHNOLOGY

Cost Element	Estimated Cost per Ton	Percent of Total
Site Material Preparation Costs	-	-
Permitting and Regulatory Costs	\$ 0.08	0.2
Capital Equipment	\$ 11.55	29.8
Start-up Costs	\$ 0.24	0.6
Labor Costs	\$ 8.83	22.8
Consumables and Supplies	\$ 2.56	6.6
Utilities	\$ 8.91	23.0
Residue Treatment and Disposal	\$ 0.18	0.5
Transportation	-	-
Monitoring and Analytical	\$ 1.11	2.9
Facility Modification, Repair, and Replacement	\$ 5.08	13.1
Site Demobilization and Restoration	\$ 0.20	0.5
TOTAL	\$ 38.74	100

4.0 TECHNOLOGY EFFECTIVENESS

The following sections discuss the sample results and effectiveness of the GFT technology to treat PCB- and metal-contaminated sediments.

4.1 DEMONSTRATION BACKGROUND

This demonstration evaluated the effectiveness of the GFT process to treat PCB- and metal-contaminated sediment. The technology evaluation consisted of pre-treatment (and pre-dryer) sediment sampling; post-dryer sediment sampling and post-melter glass; and air, quench-water, and cooling-tower-water sampling during treatment.

Sediment used in this demonstration was obtained from the Lower Fox River during the 1999-2000 Sediment Management Unit (SMU) 56/57 pilot dredging project, which included hydraulic dredging, onshore dewatering, filter pressing, treatment with lime, and disposal of PCB-contaminated sediment. The sediment removal action was conducted adjacent to the Fort James Corporation facility in Green Bay, and dewatered sediment was disposed of at the Fort James Landfill, while all treated water was returned to the river. WDNR conducted oversight on the project with funding from the Fox River Group. The SMU 56/57 project goal was to generate information to assess the effectiveness and expense for large-scale sediment dredging and disposal of contaminated sediment from the Lower Fox River.

In general, the dredging project consisted of hydraulic dredging of a portion of the river bottom into two lined settling basins. After the solids settled out, they were pumped to plate-and-frame presses for mechanical dewatering. Lime was added, on an as-needed basis, to aid solidification, and the sediment was transported to the Fort James Landfill for disposal. Water was treated with sand filtration and activated carbon before it was discharged back into the Lower Fox River.

A portion of the sediment from the SMU 56/57 project was segregated for the purpose of the SITE evaluation of the GFT, an innovative sediment-treatment technology. On December 17, 1999, rather than loading all dredged-and-dewatered sediment into trucks for transport and disposal, a portion was loaded into four lined 20-cubic-yard roll-off boxes. The boxes were covered and transported to the Brown County Landfill in Green Bay, Wisconsin, where the sediment was temporarily stored until the GFT evaluation.

4.2

METHODOLOGY AND TECHNOLOGY IMPLEMENTATION

This section details activities conducted prior to and during the GFT demonstration. The evaluation was arranged to scientifically verify Minergy's claims and to assess the effectiveness of the GFT in meeting project objectives. Objectives form the basis for the evaluation and provide a measure by which performance of the technology can be measured. Elements of the experimental approach and the procedures involved, conducted during both the dryer and melter demonstrations, are presented in the following sections. Table 4-1 summarizes the events and dates of the demonstrations.

TABLE 4-1
SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION DEMONSTRATION EVENTS

Event	Duration
Dryer Demonstration at Hazen Research, Golden, Colorado	January 23 through 25, 2001
Dredged-and-Dewatered Sediment Sampling from Roll-off Boxes at Minergy Facility, Winneconne, Wisconsin	April 24 and May 7, 2001
Dried Sediment Sampling from Supersacks after Drum Dryer at Minergy Facility, Winneconne, Wisconsin	June 4 and 5, 2001
GFT Melter Demonstration at Minergy Facility, Winneconne, Wisconsin	June 19 through 23, 2001 and August 14 through 17, 2001
Glass Samples Crushed at UW-Platteville, Platteville, Wisconsin	August 22 and 23, 2001

4.2.1 Pre-demonstration Activities

Before sediment could be fed into the melter, the moisture content needed to be reduced from a dewatered condition (50 percent) to a moisture content of 5 to 15 percent for optimal melter efficiency. Minergy researched available drying technologies and determined that an indirect heat disc or paddle dryer unit was the most appropriate drying technology for the GFT treatment process; however, no production-sized dryers of this type were available for use at the Minergy facility or elsewhere. Therefore, Minergy set up a bench-scale demonstration of a Holoflute[®] dryer at the Hazen facility in Golden, Colorado, to provide data on a unit similar to that intended for use by Minergy in the full -scale design.

4.2.1.1 Hazen Research Inc. Dryer Demonstration

Based on the dust carryover into the air and condensate streams, it was evident that the results were strongly influenced by the contamination in the dust and should be disregarded. The size of the bench-scale Holoflite® dryer also proved to be inadequate to achieve the evaluation objectives. Appendix C contains details of the Hazen Holoflite® dryer demonstration.

4.2.1.2 Drum Dryer

The dryer selected by Minergy to dry the bulk of the sediment to be used in the melter demonstration was not suitable for sampling and evaluation of its potential waste streams. Minergy had planned the dryer test to be a bench-scale demonstration only, using a portion of the sediment. The rest of the sediment stored in the roll-off boxes was to be dried using a different technology. The dredged-and-dewatered sediment was manually shoveled from the roll-off boxes into 55-gallon drums. The drums were placed, 12 at a time, into a drum oven, where they were heated for about 36 hours, until the sediment contained about 10 percent moisture. The drum oven was chosen, because it was electrically heated and could be set up for low-temperature drying, with minimal air circulation. Each dried, 12-drum batch was transferred to two supersacks, weighing about 1,000 pounds each. Thirty batches of sediment were dried in the drum oven, yielding 60 supersacks of dried sediment. Each supersack was numbered to designate from which roll-off box the sediment originated.

4.2.2 Glass Furnace Technology Melter Demonstration

The melter-demonstration evaluation was designed to collect six composite samples of the sediment entering the melter and six composite samples of glass aggregate product exiting the melter. These samples would provide the data necessary to evaluate the primary objectives. In addition, samples were collected from all waste streams of the melter, including air, quench-tank water, cooling-tower water, accumulated dust, and flux.

4.2.2.1 June 2001 Glass Furnace Technology Demonstration

Minergy initially began the GFT demonstration on June 19, 2001. The demonstration began with the melter warmup and introduction of sediment. Minergy began melting sediment segregated for the SITE

demonstration early on the morning of June 20, 2001. Sediment grab samples were collected at 15-minute intervals over a 6-hour period. Glass aggregate product samples were collected at 15-minute intervals over a 6-hour period. Glass-aggregate-product sampling began after completion of the 6-hour sediment feed sampling. The sampling protocol was arranged to account for the 6-hour residence time within the melter, so that sampled glass aggregate corresponded with sampled sediment.

The initial demonstration suffered problems associated with the flow of sediment feed and the effluent flow of the molten glass from the weir of the melter. The lack of fluidity of the molten glass caused many interruptions of the flow from the melter and forced adjustments to the sampling schedule. In cases where flow was interrupted for a significant period of time, sampling of the glass aggregate was suspended until flow was restored. Upon restoration of the molten glass flow, sampling resumed at shorter intervals to collect the required volume of glass aggregate within the 6-hour sampling period. These conditions persisted over the first 2 days of the melter demonstration.

On the third day of the demonstration, molten glass began leaking through the side of the melter at the forehearth and spilled onto the floor. The leak location was immediately doused with cold water, and project stakeholders decided to halt the demonstration due to the hazardous conditions resulting from the melter leak. The molten sediment was more corrosive to the originally selected refractory brick than previously predicted. The melter was rebuilt with an improved grade of refractory and the demonstration was re-scheduled.

4.2.2.2 August 2001 Glass Furnace Technology Demonstration

The melter demonstration restarted on August 13, 2001, with melter warming, sediment introduction, and sampling of the sediment, glass, and other waste streams from the melter operation. Less sediment was available for this demonstration as a result of the failed first attempt, so two sampling runs were conducted each day, rather than one. This schedule was necessary due to a shortened melter demonstration period.

The melter operated continuously throughout the August-demonstration period. Sediment and glass sampling began on August 14 and ended August 16, 2001. Molten glass continued to flow from the melter as long as sediment entered the melter. The sampling probe that was inserted into the flue to collect air samples was a source of intermittent problems caused by plugging with what was thought to be flux material. The material buildup resulted in the periodic interruption of air sampling so that the probe

could be cleaned. The interruption of flow lengthened the time needed to collect individual air samples; consequently, the air sampling team worked in shifts to cover the sampling 24 hours per day. Air sampling activities continued for 5 days and ended on August 17, 2001, while sediment and glass sampling was completed in 3 days.

All of the melter data presented in this ITER were generated during the August 2001 demonstration.

4.2.3 Sampling Program

To facilitate evaluation of the technology, a sampling program was designed to assess the GFT's capacity to meet the objectives outlined above. The sampling program was detailed in the quality assurance project plan (QAPP) (EPA 2001) before the demonstration was begun.

The roll-off boxes were delivered to Minergy's facility in Winneconne, Wisconsin, and thawed. A hand auger was used to collect sediment samples from randomly selected locations within the roll-off boxes. Those samples were composited by coning and quartering on a plastic sheet. Six composite sediment samples were collected from the roll-off boxes. The material in the roll-off boxes was subsequently processed in the drum dryer.

4.2.3.1 Drum Dryer

Because the SITE evaluation intended to use data collected from an indirect disc or paddle dryer, sampling of the drum dryer was not outlined in the QAPP. After the data from the bench-scale dryer were determined to be inadequate, it was decided to collect samples of the dredged-and-dewatered sediment entering the drum dryer and as well as the dried sediment exiting the drum dryer. No samples of air or condensate emitted by the dryer were sampled. The drum dryer was not configured to allow for sampling of the exhaust or condensate.

4.2.3.2 Glass Furnace Technology Melter

Sampling of the GFT melter was planned to obtain corresponding samples of sediment entering the melter, glass aggregate product exiting the melter, and quench water used to cool the molten glass. Air and other samples collected during the demonstration were not meant to parallel sediment and glass samples. Sediment and glass samples were collected as composite samples, to assess the uniformity, as well as potential contaminant losses, of the sediment feed and glass product. Composites consisted of 24 individual grab samples gathered every 15 minutes over a 6-hour period. Quench-water composite samples consisted of 12 grab samples collected over a 6-hour period.

Ancillary media samples, such as air, cooling tower discharge water, city water, and flux were not collected as composite samples. Forty air samples were collected to be analyzed for PCBs, dioxins and furans, semi-volatile organic compounds (SVOCs), metals, VOCs, and hydrogen chloride/chlorine. For the August 2001 demonstration, sediment and glass sampling was completed in 3 days, while air sampling required five 24-hour sampling days to collect the desired number of samples.

4.3 GFT DEMONSTRATION DATA

This section presents the results of data gathered for the drum dryer and GFT melter during the SITE demonstration. Sediment, glass, air, and water sampling results and operating data were used to evaluate the performance of the GFT in relation to evaluation objectives. Sampling results are shown in Tables 4-2 through 4-12. Significant figures used to report analytical data in the tables and text of this report reflect the same number of significant figures reported by the laboratories. All solids results are reported on a dry-weight basis.

4.3.1 Dryer

Data collected from the sampling of the dredged-and-dewatered sediment in the roll-off boxes and the dried sediment in the supersacks at the Minergy facility in Winneconne, Wisconsin, were used to calculate the Treatment Efficiency (TE) of the GFT. Results of the before and after dryer samples collected in Winneconne, Wisconsin, are detailed in the following sections. As mentioned in Section 4.2.1.1, results of the Holoflute® dryer sampling are detailed in Appendix C, but are not used in the evaluation of the GFT.

4.3.1.1 Dredged-and-Dewatered Sediment

To evaluate the GFT process as a whole, dredged-and-dewatered (wet) sediment samples were collected from the roll-off boxes.

Composite samples were analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by EPA Method 680 (EPA 1985). The results of the analyses are presented in Table 4-2. Total PCB results were calculated by summing the concentration of homologs (series of PCBs where each successive member has one additional chlorine). Non-detect values were not used in this calculation. These concentrations ranged from 20.1 to 35.9 ppm.

4.3.1.2 Drum-Dried Sediment

Six composite samples were collected from the supersacks containing drum-dried sediment and were analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by EPA Method 680 (EPA 1985). Total PCB results, calculated by summing the concentration of PCB homologs, are reported in Table 4-3. The results range from 20.5 to 25.0 ppm.

**TABLE 4-2
DREDGED-AND-DEWATERED SEDIMENT RESULTS**

Analyte PCBs (Method 680) (ng/g)	Sample Identification					
	Rolloff #3			Rolloff #4		
	Lift 1	Lift 2	Lift 3	Lift 1	Lift 2	Lift 3
(1)-MoCB	260	279	190	275	<341	277
(4,10)-DiCB	1,050	1,010	642	842	879	721
(9,7)-DiCB	195	198	113	164	165	132
(6)-DiCB	1,630	1,680	942	1,390	1,350	1,090
(5,8)-DiCB	2,010	2,040	1,150	1,740	1,660	1,350
(19)-TriCB	302	292	172	252	248	201
(18)-TriCB	2,700	2,750	1,460	2,210	2,090	1,690
(17)-TriCB	1,500	1,470	823	1,260	1,210	988
(27,24)-TriCB	326	321	184	278	270	220
(16,32)-TriCB	1,850	1,860	1,030	1,570	1,490	1,220
(29)-TriCB	<4.39	<4.67	<3.59	5.25	<4.61	<4.20
(26,25)-TriCB	2,820	2,890	1,570	2,440	2,280	1,880
28,(31)-TriCB	7,350	7,320	4,060	6,320	5,920	4,860
(21,33,20)-TriCB	825	793	459	721	683	552
(22)-TriCB	851	828	484	752	718	578
(37)-TriCB	554	508	316	500	469	381
(53)-TeCB	274	278	151	232	221	182
(45)-TeCB	271	280	154	234	226	185
(46)-TeCB	104	108	58.6	90.4	84.9	70.6
(43),52-TeCB	1,540	1,550	860	1,330	1,260	1,040
(49)-TeCB	1,190	1,190	666	1,030	984	820
(47,48,75)-TeCB	646	625	362	557	539	446
(44)-TeCB	1,070	1,140	603	1,100	900	746
(59,42)-TeCB	588	592	341	354	485	423
(41,71,72)-TeCB	628	636	358	554	531	440
(64,68)-TeCB	879	870	499	774	745	613
(40)-TeCB	214	224	124	190	183	150
(63)-TeCB	108	105	61.6	96.0	93.6	77.7
(74)-TeCB	483	463	276	434	417	340
(70)-TeCB	637	578	357	566	537	442
(66,80)-TeCB	654	616	378	605	573	460
(56,60)-TeCB	517	498	300	470	453	364
(77)-TeCB	148	141	85.8	135	131	111
(91)-PeCB	55.7	54.3	32.4	49.8	48.0	39.9
(84)-PeCB	83.1	86.8	49.9	75	71.2	59.9
(101,113)-PeCB	150	145	91.3	138	131	104
(99)-PeCB	94.0	90	56.5	86.1	82.4	68.2
(119,112)-PeCB	14.6	13.9	9.00	14.1	13.4	10.7
(86,97,125)-PeCB	61.2	59.7	36.9	55.4	53.0	44.0
(87,111,115)-PeCB	72.6	72.9	44.8	68.0	63.7	53.1
(85)-PeCB	45.7	45.4	27.3	41.4	40.5	33.8
(110)-PeCB	302	295	184	280	266	223

**TABLE 4-2
DREDGED-AND-DEWATERED SEDIMENT PCB RESULTS (CONTINUED)**

Analyte PCBs (Method 680) (ng/g)	Sample Identification					
	Rolloff #3			Rolloff #4		
	Lift 1	Lift 2	Lift 3	Lift 1	Lift 2	Lift 3
(82)-PeCB	31.0	30.0	19.2	28.3	26.5	23.2
(123)-PeCB	<4.39	<4.67	<3.59	<3.50	20.8	<4.20
118-PeCB	163	152	97.3	147	139	115
(114)-PeCB	10.6	10.4	<3.59	<3.50	8.01	7.65
(136)-HxCB	17.6	16.0	<11.8	15.3	15.7	12.5
(151)-HxCB	22.4	21.2	14.3	20.3	19.1	15.9
(135)-HxCB	16.9	15.8	<13.0	15.4	14.8	12.3
(139,149)-HxCB	76.9	67.2	45.9	69.2	66.1	55.4
(146,161)-HxCB	19.6	17.1	11.0	18.1	16.8	13.6
(132),153,(108)-HxCB	113	97.4	67.3	101	94.3	80.5
(141)-HxCB	14.6	13.3	8.66	13.3	12.0	10.6
(137)-HxCB	4.62	<4.67	<3.59	4.2	<4.61	<4.20
(138,160)-HxCB	58.9	51.3	34.8	37.6	47.1	43.0
(158)-HxCB	6.93	8.87	5.31	48.7	6.81	5.14
(128)-HxCB	10.6	8.90	7.03	9.15	10.2	8.43
(167)-HxCB	7.22	<5.88	<3.59	<3.50	<4.61	4.71
(156)-HxCB	<9.38	<12.4	<8.54	<8.23	<4.61	6.78
(157)-HxCB	<4.39	<4.67	<29.0	9.96	<4.61	19.4
(176)-HpCB	4.76	<4.67	<3.59	<3.50	<4.61	<4.20
(178)-HpCB	5.98	5.60	<3.66	5.36	<5.16	4.23
(182,187)-HpCB	34.3	29.7	18.7	31.5	29.4	24.7
(183)-HpCB	14.4	12.8	<8.78	12.9	12.1	10.5
(174,181)-HpCB	21.9	20.5	12.4	20.1	21.0	15.0
(177)-HpCB	14.2	12.9	7.67	13.2	13.7	9.89
180,(193)-HpCB	57.3	51.4	<33.5	53.0	50.0	40.3
(170,190)-HpCB	26.2	22.2	13.4	22.5	21.7	18.5
(196,203)-OcCB	11.4	<12.0	<7.39	10.4	<11.3	7.57
(206)-NoCB	9.57	7.84	5.55	7.47	7.65	5.56
(209)-DeCB	5.40	4.99	<3.59	4.43	<4.61	<4.20
PCBs (Method 680) homolog sum (ng/g)	35,900	35,700	20,100	31,100	29,300	24,300

Notes:

ng/g – Nanogram per gram

PCBs = Polychlorinated biphenyls

PCB congeners less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Results are reported on a dry-weight basis.

TABLE 4-3
DRUM-DRIED SEDIMENT PCB RESULTS

Analyte PCBs (Method 680) (ng/g)	Sample Identification					
	Rolloff #3			Rolloff #4		
	A	B	C	A	B	C
(1)-MoCB	86.2	<71.4	88.2	<76.0	67.9	56.9
(4,10)-DiCB	400	332	436	363	308	310
(9,7)-DiCB	100	87.9	108	91.9	79.5	84.3
(6)-DiCB	855	753	924	803	691	741
(5,8)-DiCB	1,110	980	1,200	1,060	910	971
(19)-TriCB	161	141	174	148	127	136
(18)-TriCB	1,500	1,360	1,640	1,430	1,250	1,360
(17)-TriCB	877	806	958	837	731	798
(27,24)-TriCB	200	185	219	192	169	181
(16,32)-TriCB	1,140	1,060	1,250	1,100	976	1,050
(26,25)-TriCB	1,850	1,750	2,020	1,840	1,650	1,770
28,(31)-TriCB	4,770	4,530	5,280	4,810	4,340	4,750
(21,33,20)-TriCB	549	527	603	553	502	539
(22)-TriCB	587	558	640	588	535	568
(37)-TriCB	379	372	414	393	364	386
(53)-TeCB	179	172	197	177	162	169
(45)-TeCB	185	175	205	183	166	174
(46)-TeCB	72.8	68.2	78.2	69.5	64.3	66.5
(43),52-TeCB	1,050	1,030	1,160	1,060	976	1,010
(49)-TeCB	824	812	911	822	767	790
(47,48,75)-TeCB	452	445	497	455	420	432
(44)-TeCB	763	760	847	758	708	741
(39,42)-TeCB	413	405	463	402	380	396
(41,71,72)-TeCB	450	452	502	451	432	441
(64,68)-TeCB	635	632	699	635	596	612
(40)-TeCB	156	155	174	156	147	153
(63)-TeCB	78	78.6	87.1	79.9	76.1	76.8
(74)-TeCB	349	359	388	358	340	348
(76)-TeCB	450	482	500	472	436	456
(70)-TeCB	484	483	532	484	472	472
(56,60)-TeCB	378	390	417	390	371	378
(77)-TeCB	108	113	120	113	109	111
(91)-PeCB	41.6	42.7	46.5	42.0	40.7	40.4
(84)-PeCB	64.3	65.2	71.6	63.5	62.7	61.8
(101,113)-PeCB	115	122	125	119	114	110
(99)-PeCB	71.6	74.8	79.7	72.1	70.6	69.9
(119,112)-PeCB	11.2	11.6	12.3	11.3	10.8	10.5
(86,97,125)-PeCB	47.1	49.1	52.1	47.6	47.1	45.4
(87,111,115)-PeCB	56.5	58.8	64.6	56.7	55.9	54.4
(85)-PeCB	35.4	37.5	39.4	35.7	35.1	34.6
(110)-PeCB	235	246	261	238	234	230

**TABLE 4-3
DRUM-DRIED SEDIMENT PCB RESULTS (CONTINUED)**

Analyte PCBs (Method 680) (ng/g)	Sample Identification					
	Rolloff #3			Rolloff #4		
	A	B	C	A	B	C
(82)-PeCB	25.4	25.6	26.7	24.2	24.7	23.9
(123)-PeCB	<2.58	<3.65	<22.8	<3.82	13.0	<2.33
118-PeCB	120	136	135	128	127	121
(114)-PeCB	7.45	<8.94	<7.75	<2.65	<2.68	<2.33
(136)-HxCB	13.0	14.6	14.2	14.4	13.1	12.7
(151)-HxCB	16.5	17.2	18.8	18.0	17.0	16.0
(135)-HxCB	13.2	14.7	17.1	13.5	12.8	12.9
(139,149)-HxCB	57.3	61.9	61.5	59.7	58.5	55.8
(146,161)-HxCB	15.7	16.3	16.6	16.2	15.2	15.3
(132),153,(168)-HxCB	84.8	92.3	91.3	89.1	86.7	84.1
(141)-HxCB	11.3	11.5	<11.5	11.2	10.0	11.1
(137)-HxCB	3.62	<2.61	<2.75	2.91	<3.04	3.59
(138,160)-HxCB	41.3	46.4	43.4	45.7	43.2	40.2
(158)-HxCB	6.58	7.36	<6.63	<6.60	7.25	5.67
(128)-HxCB	8.38	<8.68	8.87	<7.82	6.97	8.35
(156)-HxCB	7.12	<2.61	<23.9	<2.65	<17.7	<6.99
(176)-HpCB	3.63	<4.74	<3.90	<4.65	<5.92	3.37
(178)-HpCB	4.43	5.15	<5.45	<4.55	<5.50	4.64
(182,187)-HpCB	26.5	28.4	29.5	28.7	26.7	26.1
(183)-HpCB	10.9	12.1	<13.0	11.1	11.9	10.7
(185)-HpCB	<2.58	2.70	<2.90	<2.65	<2.68	<2.33
(174,181)-HpCB	17.0	17.7	20.2	18.1	17.9	16.2
(177)-HpCB	<11.0	<26.3	12.0	<11.6	<18.0	11.0
(172)-HpCB	2.85	2.86	<2.75	3.33	<2.97	2.36
180,(193)-HpCB	43.2	48.8	<51.4	46.9	44.6	43.5
(170,190)-HpCB	18.8	21.2	21.4	20	19.6	19.3
(196,203)-OcCB	8.20	8.78	<11.2	8.57	8.78	8.14
(208)-NoCB	<2.58	<2.61	2.98	<2.65	3.51	<2.33
206-NoCB	6.24	7.44	8.13	6.98	6.38	5.87
209-DeCB	2.74	<3.81	3.81	2.91	3.91	2.71
PCBs (Method 680) Congener sum (ng/g)	22,800	21,700	25,000	22,500	20,500	21,700

Notes:

ng/g = Nanogram per gram

PCBs = Polychlorinated biphenyls

ND = Not detected; analytes were less than detection limits of laboratory instruments. Laboratory did not specify detection limits.

PCB congeners less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

4.3.2 Melter

The melter-phase of the demonstration was conducted at Minergy's facility in Winneconne, Wisconsin. The pilot-scale melter (glass furnace) was built to produce 2 tons of glass aggregate per day. The melter was designed to run on an oxygen-and-natural-gas mixture to burn more efficiently and produce higher temperatures, which should result in lower emissions of nitrogen oxides in the furnace flue gas. The melter was built with refractory brick that was selected based on an analysis of heat flow and the bricks' ability to cope with the corrosive qualities of molten sediment. The retention time of sediment in the melter was 6 hours, after which the molten sediment flowed from the melter into a water-quench tank. The molten sediment quickly cooled and cracked, producing a black glass aggregate product.

4.3.2.1 Melter Feed Dry Sediment

The drum-dried sediment was divided into 50-pound plastic bags for handling and tracking purposes. The dried sediment was fed into the melter at a rate of 200 pounds per hour over a 5-day period. Dried sediment was sampled every 15 minutes (once per 50-pound bag) as it was entering the screw feeder. A 4-ounce sample was collected from the bag and was placed in a disposable aluminum pan to be composited with other grab samples collected over the 6-hour sample collection period. Upon accumulation of all grab samples, the composite sample was mixed, using a coning-and-quartering technique. Analytical samples then were collected from the mixed composite sample.

PCBs

Composite samples, analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by EPA Method 680 (EPA 1985), are listed in Table 1-1 of the QAPP (EPA 2001). Total PCB results, calculated by summing the concentration of homologs, ranged from 21,500 to 30,900 nanograms per gram (ng/g) (21.5 to 30.9 ppm). Table 4-4 contains analytical results from those composite samples of sediment.

The concentrations observed in the dried sediment are similar to concentrations observed in dredged-and-dewatered sediment samples.

**TABLE 4-4
MELTER FEED DRY SEDIMENT COMPOSITE SAMPLE RESULTS**

Analyte	Sample Identification					
	M-S-01	M-S-02	M-S-03	M-S-04	M-S-05	M-S-06
PCBs (Method (680) (ng/g)						
(1)-MoCB	99.0 E	77.2	79.9	92.3	62.7	51.7
(4,10)-DiCB	445 E	40.3 E	446 E	418 E	351 E	287 E
(9,7)-DiCB	111 E	109	117 E	107	99.4	79.5
(6)-DiCB	1,170 E	1,130 E	1,230 E	1,070 E	1,030 E	776 E
(5,8)-DiCB	1,330 E	1,290 E	1,420 E	1,260 E	1,190 E	922 E
(19)-TriCB	182 E	174 E	187 E	173 E	162 E	121 E
(18)-TriCB	1,840 E	1,790 E	1,960 E	1,730 E	1,720 E	1,270 E
17(TriCB)	1,080 E	1,040 E	1,140 E	1,010 E	986 E	729 E
(27,24)-TriCB	232 E	228 E	241 E	219 E	215 E	158 E
(16,32)-TriCB	1,360 E	1,340 E	1,430 E	1,290 E	1,290 E	950 E
(26,25)-TriCB	1,300 E	2,290 E	1450 E	2,130 E	2,180 E	1,590 E
(28,31)-TriCB	6,090 E	6,290 E	6,020 E	6,060 E	6,210 E	4,580 E
(21,33,20)-TriCB	677 E	693 E	737 E	656 E	668 E	493 E
(22)-TriCB	703 E	724 E	744 E	668 E	687 E	509 E
(37)-TriCB	458 E	477 E	494 E	439 E	457 E	341 E
(53)-TeCB	211 E	210 E	219 E	202 E	204 E	147 E
(45)-TeCB	217 E	215 E	225 E	208 E	209 E	150 E
(46)-TeCB	84.3	83.7	86.5	81.5	81.7	59.2
(43),52-TeCB	1,240 E	1,260 E	1,300 E	1,180 E	1,220 E	871
(49)-TeCB	997 E	1,010 E	1040 E	962 E	995 E	704 E
(47,48,75)-TeCB	518 E	516 E	531 E	481 E	497 E	369 E
(44)-TeCB	997 E	998 E	1,040 E	954 E	973 E	605 E
(59,42)-TeCB	422 E	432 E	432 E	393 E	414 E	305 E
(41,71,72)-TeCB	548 E	549 E	568 E	532 E	546 E	382 E
(64,68)-TeCB	753 E	764 E	784 E	708 E	742 E	544 E
(40)-TeCB	199 E	196 E	204 E	188 E	179 E	133 E
(63)-TeCB	94.4	96.8	99.4	89.9	93.9	67.8
(74)-TeCB	417 E	428 E	436	399 E	421 E	304 E
(70)-TeCB	639 E	630 E	649 E	573 E	638 E	480 E
(66,80)-TeCB	488 E	514 E	529 E	493 E	493 E	341 E
(56,60)-TeCB	446 E	461 E	468 E	428 E	446 E	330 E
(77)-TeCB	160 E	145 E	128 E	131 E	136 E	101
(91)-PeCB	49.2	49.4	50.3	46.8	48.6	34.5
(84)-PeCB	50.3	53.9	46.8	49.7	51	36.1
(101,113)-PeCB	148 E	151 E	153 E	140 E	149 E	107 E
(99)-PeCB	82.8	84.5	85.9	78.8	83.4	59.5
(119,112)-PeCB	12.4	12.6	12.5	12.1	11.7	9.26
(86,97,125)-PeCB	53.9	56.4	56.1	52.0	53.5	39.6
(87,111,115)-PeCB	77.5	66.4	80.6	63.3	65.8	56.4
(85)-PeCB	39.2	40.5	40.7	38.3	38.9	28.5
(110)-PeCB	279 E	283 E	289 E	265 E	277 E	201 E
(82)-PeCB	27.2	31.3	29.2	27.1	27.1	20.5

TABLE 4-4
MELTER FEED DRY SEDIMENT COMPOSITE SAMPLE RESULTS (CONTINUED)

Analyte	Sample Identification					
PCBs (Method (680) (ng/g)	M-S-01	M-S-02	M-S-03	M-S-04	M-S-05	M-S-06
(107)-PeCB	5.2	<4.14 P	<3.88 P	<4.77 P	<4.21 P	<1.27
(123)-PeCB	<22.2 P	<22.6 P	<21.7 P	<19.3 P	<19.7 P	15
(118)-PeCB	148 E	151 E	155 E	139 E	148 E	108
(136)-HxCB	<1.36	<1.39	14.6	13.2	14.6	107 E
(151)-HxCB	17.8	18.3	19.6	17.2	17.9	14.3
(135)-HxCB	<1.36	13.9	16.8	14.9	13.6	<1.27
(139,149)-HxCB	58.9	62.0	65.2	56.2	60.9	46.1
(146,161)-HxCB	15.5	15.6	15.5	14.1	<1.35	12.7
(132,153,168)-HxCB	90.9	91.8	95.5	82.7	90.5	70.0
(141)-HxCB	11.5	<1.39	<10.8 P	10.4	<1.35	<1.27
(137)-HxCB	3.44	<3.00 P	<2.72 P	<1.39	<1.35	<1.27
(138,160)-HxCB	34.6	33.8	32.5	44.0	46.7	35.5
(158)-HxCB	49.2	51.4	47.7	<1.39 P	<1.35	<1.27
(176)-HpCB	<3.35 P	3.64	3.89	3.16	2.88	2.34
(178)-HpCB	4.23	4.51	4.74	4.04	<1.35	3.27
(182,187)-HpCB	26.8	28.4	28.6	25.9	<1.35	20.9
(183)-HpCB	<11.2 P	11.8	12.9	10.7	11.9	8.75
(185)-HpCB	2.15	2.27	<1.41 P	1.78	<1.35	<1.27
(174,181)-HpCB	18.9	17.8	18.8	16.4	17.2	13.6
(177)-HpCB	<1.36	<1.39	12.4	10.8	<1.35	9.50
(172)-HpCB	<1.36	<1.39	2.86	2.66	<1.35	2.46
(180,193)-HpCB	48.7	46.1	50.5	44.3	<1.35	37.4
(170,190)-HpCB	<20.8 P	<1.39	21.4	18.6	<1.35	15.4
(202)-OcCB	<1.36	<1.39	2.01	2.04	2.17	1.48
(196,203)-OcCB	<1.36	8.25	8.41	7.67	7.87	6.13
(208)-NpCB	<1.36	<1.39	<22.5 P	2.00	2.15	<1.27
(206)-NoCB	7.42	6.77	6.99	6.36	7.27	5.91
(209)-DeCB	2.85	10.6	3.22	3.96	3.06	2.23
Total PCBs (homolog sum) (ng/g)	29,700	30,900	30,900	26,200	29,100	21,500
Metals (mg/kg)	M-S-01	M-S-02	M-S-03	M-S-04	M-S-05	M-S-06
Arsenic	7.3	8.0	8.1	8.5	<5.9	<5.5
Barium	96	84	85	91	83	87
Cadmium	0.86	0.83	0.90	0.90	0.85	0.93
Chromium	39	37	38	39	36	37
Mercury	0.68	0.87	0.70	0.64	0.76	0.66
Lead	69	68	69	87	69	69
Selenium	10 J	6 J	6.5	6.7	<5.9	<5.5
Silver	<2.3	<2.3	<2.3	<2.3	<2.4	<2.2
PCDD/Fs (pg/g)	M-S-01	M-S-02	M-S-03	M-S-04	M-S-05	M-S-06
2,3,7,8-TCDD	14.8	28.0	12.8	13.4	52.8	18.9
1,2,3,7,8-PeCDD	29.5	41.0	27.6	29.5	93.6	49.0
1,2,3,4,7,8-HxCDD	234	240	245	234	241	235
1,2,3,6,7,8-HxCDD	254	251	284	262	289	310

TABLE 4-4
MELTER FEED DRY SEDIMENT COMPOSITE SAMPLE RESULTS (CONTINUED)

Analyte	Sample Identification					
PCDD/Fs (pg/g)	M-S-01	M-S-02	M-S-03	M-S-04	M-S-05	M-S-06
1,2,3,7,8,9-HxCDD	107	117	140	125	212	182
1,2,3,4,6,7,8-HpCDD	9,330	9,940	9,870	9,130	8,880	8,470
OCDD	56,500	63,100	67,300	62,300	61,000	48,500
2,3,7,8-TCDF	63.0	66.3	65.0	60.8	56.9	81.6
1,2,3,7,8-PeCDF	14.0	18.1	17.6	16.0	14.3	19.8
2,3,4,7,8-PeCDF	28.2	32.0	35.1	34.7	34.8	39.4
1,2,3,4,7,8-HxCDF	27.1	28.9	31.3	29.1	29.2	40.0
PCDDs/PCDFs (Method 8290) (pg/g)	M-S-01	M-S-02	M-S-03	M-S-04	M-S-05	M-S-06
1,2,3,6,7,8-HxCDF	25.9	26.5	28.7	27.6	28.9	30.4
2,3,4,6,7,8-HxCDF	41.7	45.3	42.1	40.5	54.6	64.2
1,2,3,7,8,9-HxCDF	4.57	<4.67	4.49	<4.01	<4.20	4.31
1,2,3,4,6,7,8-HpCDF	622	756	684	623	620	546
1,2,3,4,7,8,9-HpCDF	20.9	26.5	28.5	22.3	22.8	21.9
OCDF	1,530	2,190	1,690	1,580	1,370	1,220
Total PCDDs/PCDFs (homolog sum) (pg/g)	101,000	111,000	115,000	106,000	107,000	168,000
SVOCs (µg/L)	M-S-01	M-S-02	M-S-03	M-S-04	M-S-05	M-S-06
Fluoranthene	<190	<190	270 J	<190	--	--
Pyrene	<190	<190	300 J	<190	--	--
Benzo(a)anthracene	<190	<190	240 J	<190	--	--
Chrysene	<190	<190	280 J	<190	--	--
Benzo(b)fluoranthene	<190	<190	340 J	<190	--	--
Benzo(k)fluoranthene	<190	<190	190 J	<190	--	--
Benzo(a)pyrene	<190	<190	270 J	<190	--	--
Total SVOCs	<190	<190	1,800	<190	--	--
VOCs (µg/kg)	M-S-01	M-S-02	M-S-03	M-S-04	M-S-05	M-S-06
Acetone	840	630	330 ND,J	<5.7	--	--
2-Butanone	150	130	150	<5.7	--	--
Total VOCs	990	760	480	<5.7	--	--

Notes:

mg/g = Milligram per gram

ng/g = Nanogram per gram

pg/g = Picogram per gram

µg/kg = Microgram per kilogram

µg/L = Microgram per liter

PCBs - Polychlorinated biphenyls

PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

SVOCs - Semivolatile organic compounds

VOCs - Volatile organic compounds

E = Estimated Value. Concentration above Upper Calibration Range.

EMPC = Estimated Maximum Possible Concentration.

J = Estimated Value, Concentration Below Lower Calibration Range.

ND,J = Estimated nondetect. Low MS/MSD recoveries

P = Not detected at raised detection limit. Ion ratio is noncompliant. Equivalent to EMPC.

-- Not sampled PCB and PCDD/PCDF congeners, SVOCs, and VOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Metals

Dried sediment composite samples were analyzed for the RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver) by EPA Methods 6010B/7471A (EPA 1996). These results are presented in Table 4-4.

Mercury was considered a critical metal for this evaluation. It is consistently observed at concentrations of about 0.72 milligrams per kilogram (mg/kg) (0.721 ppm) in all pre-melter sediment samples.

Dioxins and Furans

The six composite samples were analyzed for dioxins and furans by EPA Method 8290 (EPA 1996). The results are presented in Table 4-4. Total dioxins and furans concentrations, calculated by summing the concentration of homologs, ranged from 101,000 to 168,000 picograms per gram (pg/g) (0.101 to 0.168 ppm).

Toxicity Equivalents (TEQs) are used to assess the risk of exposure to a mixture of dioxin-like compounds. Because dioxins differ in their toxicity, the toxicity of each component in the mixture are accounted for in estimating the overall toxicity. To do so, toxicity equivalency factors (TEFs) have been developed that compare the toxicity of different dioxins. Given these TEFs, provided in EPA Method 8290, the toxicity of a mixture can be expressed in terms of its TEQ, which is the amount of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin it would take to equal the combined toxic effect of all the dioxins found in that mixture. TEQs were not assessed as part of the GFT demonstration evaluation. All of the TEQs observed exceed the Agency for Toxic Substances and Disease Registry (ATSDR) screening level of 50 parts per trillion (ppt).

SVOCs

Four composite samples of dried sediment were collected and analyzed for SVOCs by EPA Method 8270C (EPA 1996). The resulting SVOC concentrations, analyzed by EPA Method 8270C (EPA 1996) are listed in Table 4-4.

Total SVOC concentrations observed in dried sediment composite samples were generally small (below detection limits in most samples), ranging from less than 190 to 1,890 micrograms per kilogram (µg/kg) (0.190 to 1.89 ppm).

VOCs

Four composite samples were collected and analyzed for VOCs by EPA Method 8260B (EPA 1996). The results of VOC analyses are listed in Table 4-4. The only VOCs observed were acetone and 2-butanone, which are suspected laboratory artifacts. Acetone and 2-butanone are typically used by laboratories to clean equipment.

4.3.2.2 Flux

One composite sample was collected from the sodium sulfate flux material and analyzed for PCBs by EPA Method 680 (EPA 1985). Total PCB results are reported in Table 4-5. PCBs were detected at a concentration of 0.79 ppm.

4.3.2.3 Glass Aggregate Product

Molten sediment exited the melter into a water-quench tank, where it cooled quickly and shattered into small pieces. This glass aggregate product was removed from the water-quench tank by a screw conveyor and discharged into 55-gallon drums. The aggregate was produced at a rate of 170 lb/hr (77 kg/hour) over the demonstration period.

The screw-conveyor discharge was sampled every 15 minutes for six hours. These samples were composited in a disposable aluminum pan. Analytical samples were collected from the mixed composite sample. The following sections detail the results of the laboratory analyses of the composited glass aggregate product samples (aggregate).

PCBs

Composite glass samples, analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by high-resolution EPA Method 1668 (EPA 1997), are listed in Appendix A. Total PCBs, calculated by summing the concentration of homologs, were reported by the laboratory and ranged from less than 26.0 to 1,240 pg/g (2.60×10^{-6} to 1.24×10^{-3} ppm). The analytical results are shown in Table 4-6.

TABLE 4-5
FLUX MATERIAL SAMPLE RESULT

Analyte	Sample Identification
PCBs (Method 680)	
(pg/g)	M-F-01
8-DiCB	36.7
18,(30)-TriCB	33.3
(26,29)-TriCB	27.1
31-TriCB	61.2
(20),28-TriCB	70.3
52-TeCB	37.2
49,(69)-TeCB	22.7
44,47,(65)-TeCB	28.3
209-DeCB	27.0
Total PCBs (homolog sum)	
(pg/g)	790
Metals (mg/kg)	M-F-01
Arsenic	<5.0
Barium	<0.50
Cadmium	<0.50
Chromium	<1.0
Lead	<5.0
Mercury	<0.25
Selenium	<5.0
Silver	<2.0
PCDDs/PCDFs (pg/g)	M-F-01
1,2,3,4,6,7,8-HpCDD	<0.639
OCDD	<3.50
OCDF	<0.399
Total PCDDs/PCDFs (pg/g)	
(homolog sum)	5.07
SVOCs (µg/kg)	M-F-01
Total SVOCs	<170

Notes:

mg/kg = Milligram per kilogram

pg/g = Picogram per gram

µg/kg = Microgram per kilogram

PCBs - Polychlorinated biphenyls

PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

SVOCs - Semivolatile organic compounds

PCB and PCDD/PCDF congeners, SVOCs, and VOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Subtotal consists of the sum of the congeners investigated.

Total PCB and PCDD/PCDF values provided by the laboratory.

TABLE 4-6
GLASS AGGREGATE PRODUCT COMPOSITE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	M-G-01	M-G-02	M-G-03	M-G-04	M-G-05	M-G-06
(6)-DiCB	<25.7	<26.0	<25.0	<24.2	<24.5	41.9
8-DiCB	49.9	<26.0	<25.0	<24.2	<24.5	40.8
18,(30)-TriCB	42.6	<26.0	<25.0	<24.2	<24.5	36.3
(26,29)-TriCB	32.7	<26.0	<25.0	<24.2	<24.5	<25.0
31-TriCB	109	<26.0	<25.0	<24.2	31.4	53.8
(20),28-TriCB	146	<26.0	26.3	<24.2	182	62.7
22-TriCB	28.2	<26.0	<25.0	<24.2	79.2	<25.0
37-TriCB	54.6	<26.0	<25.0	<24.2	84.3	<25.0
(45,51)-TeCB	<25.7	<26.0	<25.0	<24.2	24.6	<25.0
49,(69)-TeCB	47.4	<26.0	<25.0	<24.2	73.9	25.8
44,47,(65)-TeCB	59.6	<26.0	<25.0	<24.2	118	35.0
(40,71)-TeCB	26.9	<26.0	<25.0	<24.2	70.2	<25.0
64-TeCB	<25.7	<26.0	<25.0	<24.2	62.3	<25.0
(61),70,74,(76)-TeCB	57.7	<26.0	<25.0	<24.2	114	<25.0
66-TeCB	43.2	<26.0	<25.0	<24.2	125	<25.0
56-TeCB	<25.7	<26.0	<25.0	<24.2	74.3	<25.0
60-TeCB	<25.7	<26.0	<25.0	<24.2	50.4	<25.0
77-TeCB	<25.7	<26.0	<25.0	<24.2	26.6	<25.0
(85,116)-PeCB	28.8	<26.0	<25.0	<24.2	29.2	<25.0
PCBs (Method 1668) (pg/g)						
Total PCBs	790	<26.0	58.1	26.5	1,240	345
Metals (mg/kg)						
Arsenic	<5.2	<5.0	<5.0	<5.0	<5.0	<5.0
Barium	330	320	320	330	350	320
Cadmium	<0.52	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium	50	48	49	49	53	52
Lead	12	12	15	16	16	14
Mercury	<0.26	<0.25	<0.25	<0.25	<0.25	<0.25
Selenium	9.2.1	8.1	8.1	7.7	<5.0	<5.0
Silver	<2.1	<2.0	<2.0	<2.0	<4.0	<2.0
PCDDs/PCDFs (Method 8290) (pg/g)						
1,2,3,7,8-PeCDD	<0.151	0.173 A	<0.165	<0.189	--	--
1,2,3,7,8-PeCDF	<0.0684	0.149 A	<0.0826	<0.111	--	--
2,3,4,7,8-PeCDF	<0.0668	0.125 A	<0.0806	<0.109	--	--
Total PCDDs/PCDFs (homolog sum) (pg/g)						
Total PCDDs/PCDFs	2.01	3.77	1.93	1.77	--	--

TABLE 4-6
GLASS AGGREGATE PRODUCT COMPOSITE SAMPLE RESULTS (CONTNUED)

Notes:

mg/kg = Milligram per kilogram

pg/g = Picogram per gram

PCBs - Polychlorinated biphenyls

PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

SVOCs - Semivolatile organic compounds

VOCs - Volatile organic compounds

A = Estimated Value, Concentration Below Lower Calibration Range. Values above EDL were used to calculate totals.

EDL = Estimated Detection Limit

J = Estimated Value, Concentration Below Lower Calibration Range.

Not sampled

PCB and PCDD/PCDF congeners, SVOCs, and VOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Subtotal consists of the sum of the congeners investigated.

Total PCB and PCDD/PCDF values provided by the laboratory.

Mainly tri- and tetra-substituted congeners were detected in the glass aggregate product composite samples. The highest concentrations found were the congeners 2,3,3'-trichloro biphenyl and 2,4,4'-trichloro biphenyl (coeluted and reported as (20),28-TriCB) , which was detected at 146 and 182 picograms per gram (pg/g) (1.46×10^{-4} to 1.82×10^{-4} ppm) in samples M-G-01 and M-G-05, respectively.

Minergy has included, in the Vendor Claims appendix of this ITER, additional information about a toxicological report.

Metals

The glass aggregate product composite samples also were analyzed for the eight RCRA metals by EPA Methods 6010B/7471A (EPA 1996). The results are shown in Table 4-6.

Barium (320 to 350 mg/kg [320 to 350 ppm]) and chromium (48 to 53 mg/kg [48 to 53 ppm]) were consistently observed in glass aggregate product composite samples. Mercury concentrations were all below detection limits.

Dioxins and Furans

Glass aggregate product samples were submitted for analysis of dioxins and furans by EPA Method 8290 (EPA 1996). The results of the dioxins and furans analysis are detailed in Table 4-6.

Total dioxin and furan concentrations, calculated by summing the concentration of homologs, ranged from 1.77 to 3.77 pg/g (1.77×10^{-6} to 3.77×10^{-6} ppm). TEQs are used to assess the risk of exposure to a mixture of dioxin-like compounds. All of the TEQs observed in glass aggregate composite samples are well below the ATSDR screening level of 50 ppt.

Minergy has included, in the Vendor Claims appendix of this ITER, additional information about a toxicological report.

SVOCs

Composite samples of the glass aggregate product were collected and submitted for analysis of SVOCs. The resulting SVOC concentrations, analyzed by Method EPA 8270C (EPA 1996), were all below detection limits.

VOCs

A glass aggregate product sample was collected and submitted for analysis by EPA Method 8260B (EPA 1996) of VOCs to verify that PCBs had not been broken down into VOCs in the glass. None of the VOC analytes was detected above detection limits.

4.3.2.4 Melter Flue Gas

As the PCB-contaminated sediment entered the melter, PCBs were removed or destroyed in the furnace atmosphere, which reached a temperature of about 1,600 °C (2,900 °F). The melter flue gas was sampled to evaluate the effectiveness of the furnace in destroying PCBs and other organic contaminants, such as dioxins and furans and SVOCs. A water-cooled probe was inserted into the melter flue to extract a portion of the flue gas for sampling. The flue gas was sampled after its temperature was reduced from 1,600 °C (2,900 °F) to about 200 °C (400 °F).

Several samples were collected for analysis of PCBs, metals, dioxins and furans, SVOCs, VOCs, and HCl/Cl₂. Depending on the analysis, the melter flue gas was sampled for various durations using sample trains specific to each method and parameter. The sample train apparatus from each sample was then recovered, and the samples were sent to a laboratory for completion of the analysis. The following sections detail the results of the laboratory analyses of melter flue gas samples.

PCBs

PCB analytical results determined by high-resolution EPA Method 1668 (EPA 1997) were reported for individual congeners on the Wisconsin State Laboratory of Hygiene list. Total PCBs, calculated by summing the concentration of homologs, also were reported by the laboratory. Total PCB results from the air samples ranged from 16.4 to 130 nanograms per dry standard cubic meter (ng/dscm) (5.54×10^{-6} to 1.27×10^{-5} ppm). Table 4-7 contains the analytical results from the melter flue gas air samples.

**TABLE 4-7
MELTER FLUE GAS SAMPLE RESULTS**

Analyte PCBs (Method 680) (ng/dscm)	Sample Identification					
	Run #1	Run #2	Run #3	Run #4	Run #5	Run #6
1-MoCB	1.06	0.576	0.398	0.516	0.383	0.707
(4)-DiCB	2.19	1.34	0.699	1.08	<0.228	<0.226
(7)-DiCB	0.531	0.324	<0.239	0.289	<0.228	<0.226
(6)-DiCB	6.85	3.39	1.95	2.08	1.21	2.75
8-DiCB	7.85	4.11	2.48	2.41	1.83	3.50
(19)-TriCB	1.03	0.440	0.279	0.308	<0.228	0.422
18,(30)-TriCB	14.1	5.13	3.03	3.15	1.88	3.82
(17)-TriCB	6.26	2.18	1.28	1.40	0.774	1.62
(27)-TriCB	1.45	0.452	0.255	0.261	<0.228	0.307
(24)-TriCB	2.84	1.16	0.649	<0.678	0.455	0.842
(26,29)-TriCB	7.14	2.16	<1.19	<1.32	<0.742	<1.49
(25)-TriCB	4.99	1.49	0.825	<0.895	<0.5283	<1.06
31-TriCB	13.4	4.64	2.55	2.71	1.78	3.00
(20),28-TriCB	12.2	4.74	2.60	2.82	1.88	3.21
(21),33-TriCB	2.22	1.47	0.697	0.736	0.638	0.750
22-TriCB	3.01	1.38	0.728	0.775	0.547	0.847
37-TriCB	0.949	0.866	0.332	0.370	0.296	0.413
(50,53)-TeCB	2.74	0.648	0.379	0.421	0.291	0.350
(45,51)-TeCB	3.40	0.834	0.530	0.583	0.417	0.476
(46)-TeCB	0.030	0.254	<0.238	<0.231	<0.228	<0.226
52-TeCB	8.73	2.66	<1.39	1.66	1.20	<1.43
49,(69)-TeCB	5.46	1.69	0.866	1.04	0.754	0.928
(48)-TeCB	<0.245	0.336	<0.238	<0.231	<0.228	<0.226
44,47,(65)-TeCB	7.22	2.47	1.30	<1.52	<1.14	<1.39
(59,62,75)-TeCB	<0.245	0.341	<0.238	<0.231	<0.228	<0.226
(40,71)-TeCB	2.24	1.08	0.592	0.571	0.476	0.571
64-TeCB	1.80	0.842	0.420	0.484	0.403	0.458
(61),70,74,(76)-TeCB	2.25	1.29	0.716	<0.747	<0.699	<0.664
66-TeCB	1.13	0.646	0.377	0.377	0.387	0.341
56-TeCB	0.448	0.384	<0.238	<0.231	<0.228	<0.226
77-TeCB	0.308	0.317	0.389	0.319	0.228	<0.226
84-PeCB	0.440	<0.242	<0.238	<0.231	<0.228	<0.226
90,101,(113)-PeCB	0.866	0.571	0.312	0.303	<0.228	0.348
86,87,97,(108),119,(125)- PeCB	0.729	0.242	0.296	0.303	0.319	0.246
(85,116)-PeCB	1.06	0.706	0.394	0.368	<0.228	<0.226
110-PeCB	<0.245	<0.242	<0.238	<0.231	0.276	0.273
118-PeCB	0.401	0.351	<0.238	<0.231	<0.228	<0.226
(147),149-HxCB	0.286	<0.242	<0.238	<0.231	<0.228	<0.226
(129),138,(163)-HxCB	0.320	0.281	<0.238	<0.231	<0.228	<0.226

**TABLE 4-7
MELTER FLUE GAS SAMPLE RESULTS (CONTINUED)**

Analyte	Sample Identification					
Metals (µg/dscm)	Run #1	Run #2	Run #3	Run #4	Run #5	Run #6
Cadmium	<1,900	<2,500	<1,800	<1,320	--	--
Chromium (Total)	<10,000	<13,000	<9,500	<5,460	--	--
Lead	<150,000	<40,000	<21,000	<26,200	--	--
Mercury	<3,700	<7,800	<1,800	<8,990	--	--
Selenium	<19,000	<26,000	<18,000	<13,200	--	--
Silver	<1,900	<3,100	<1,990	<1,320	--	--
PCDDs/PCDFs (Method 8290) (ng/dscm)						
2,3,7,8-TCDD	0.009 EMPC	0.012 EMPC	<0.0038	<0.0087	<0.0061	<0.0024
1,2,3,7,8-PeCDD	0.015	0.047	0.012	0.028	0.007	0.004
1,2,3,4,7,8-HxCDD	0.019	0.044	0.012	0.021	0.006	0.007
1,2,3,6,7,8-HxCDD	0.057	0.131	0.043	0.084	0.023	0.026
1,2,3,7,8,9-HxCDD	0.028	0.065	0.023	0.071	0.014	0.014
1,2,3,4,6,7,8-HpCDD	0.531	0.624	0.174	0.298	0.092	0.115
OCDD	0.883	0.723	0.170	0.218	<0.10	<0.12
2,3,7,8-TCDF	0.022	0.100	0.028	0.034	<0.011	0.015
1,2,3,7,8-PeCDF	0.030	0.158	0.035	0.054	0.017	0.021
2,3,4,7,8-PeCDF	0.056	0.222	0.050	0.070	0.022	0.026
1,2,3,4,7,8-HxCDF	0.073	0.271	0.067	0.115	0.037	0.049
1,2,3,6,7,8-HxCDF	0.060	0.186	0.047	0.072	0.024	0.029
2,3,4,6,7,8-HxCDF	0.081	0.162	0.034	0.046	0.017	0.016
1,2,3,7,8,9-HxCDF	0.025	0.067	0.014	0.020	0.007	0.007
1,2,3,4,6,7,8-HpCDF	0.274	0.551	0.132	0.227	0.077	0.088
1,2,3,4,7,8,9-HpCDF	0.037	0.069	0.016	0.023	0.011	0.012
OCDF	0.242	0.239	0.078	0.106	0.051	0.077
SVOCs (ng/dscm)						
Benzoic Acid	143,000	140,000	--	--	--	--
Bis (2-ethylhexyl) phthalate	22,000	3,590	--	--	--	--
2-Methylphenol	5,020	3,590	--	--	--	--
3- & 4-Methylphenol	3,860	3,590	--	--	--	--
2-Nitrophenol	4,630	4,310	--	--	--	--
Phenol	7,720	3,590	--	--	--	--
Total SVOCs	186,000	159,000	--	--	--	--
VOCs (ng/dscm)						
Bromomethane	46.5	18.6	--	--	--	--
Carbon Disulfide	14.0	34.4	--	--	--	--
Methylene Chloride	17.3	19.8	--	--	--	--
Benzene	18.2	18.7	--	--	--	--

Toluene	146	99.1	--	--	--	--
Total VOCs	242	191	--	--	--	--
Analyte	Sample Identification					
	Run #1	Run #2	Run #3	Run #4	Run #5	Run #6
HCl/Cl ₂ (µg/dscm)						
HCl	54,600	140,000	27,600	57,300	--	--
Cl ₂	4,380	838	37,900	137	--	--

Notes:

Cl₂ - Chlorine

HCl - Hydrogen chloride

µg/dscm = Microgram per dry standard cubic meter

ng/dscm = Nanogram per dry standard cubic meter

PCBs - Polychlorinated biphenyls

PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

SVOCs - Semivolatile organic compounds

VOCs - Volatile organic compounds

EMPC = Estimated Maximum Possible Concentration.

-- Not sampled

PCB and PCDD/PCDF congeners, SVOCs, and VOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Total PCB and PCDD/PCDF values equal the sum of the congeners investigated.

Metals

Melter flue gas samples were analyzed for RCRA metals by Methods 6010B/7471A (EPA 1996).

Individual metals were analyzed, and their resulting concentrations observed in the flue gas are detailed in Table 4-7.

Metals concentrations in the melter flue gas samples were all below detection limits.

Dioxins and Furans

Melter flue gas air samples were submitted for analysis of dioxins and furans by EPA Method 8290 (EPA 1996). Results of the dioxins and furans analysis are detailed in Table 4-7.

Total dioxin and furan concentrations, calculated by summing the concentration of homologs, for air samples collected during the demonstration ranged from 0.406 to 3.66 ng/dscm. (3.14×10^{-8} to 2.22×10^{-7} ppm).

SVOCs

Air samples of melter flue gas were collected and submitted for analysis of SVOCs. The resulting SVOC concentrations, analyzed by EPA Method 8270C (EPA 1996), are summarized in Table 4-7.

Two samples were analyzed for SVOCs. The resulting concentrations in air samples were 186,000 and 159,000 ng/dscm. (0.0342 and 0.0284 ppm).

VOCs

Melter flue gas samples were collected and submitted for analysis of VOCs. Two samples were analyzed for VOCs, and the resulting concentrations, which were analyzed by EPA Method 8260B (EPA 1996), are summarized in Table 4-7.

VOC concentrations observed in the two air samples collected from the melter flue gas were 242 and 191 ng/dscm (7.43×10^{-6} and 6.17×10^{-6} ppm).

HCl/Cl₂

Melter flue gas was also sampled for hydrogen chloride (HCl) and chlorine (Cl₂), which were analyzed by EPA Method 26A. The flue gas was sampled for HCl/Cl₂ verify that the destruction of PCBs in the furnace did not create other pollutants. The resulting concentrations of HCl ranged from 27,600 to 140,000 ng/dscm (18 to 94 ppm). Concentrations of Cl₂ in the melter flue gas ranged from 137 to 37,900 ng/dscm (<0.047 to 13 ppm). Table 4-7 contains the results of the HCl/Cl₂ analyses for four sampling runs.

4.3.2.5 Post-Carbon Treatment Flue Gas

The melter flue gas stream passed through a carbon filter unit prior to discharge to the atmosphere. This stream was sampled after the carbon filter to evaluate the effectiveness of carbon treatment. Three samples of this stream were extracted into sampling bags and analyzed for PCB congeners, PCDDs/PCDFs, metals and SVOCs. The results are reported in Table 4-8.

4.3.2.6 Quench-Tank Water

The quench tank was situated at the end of the melter furnace, beneath the forehearth, where the molten sediment exited the melter. The molten sediment dropped into the quench tank, where it cooled immediately into black glass and shattered into small pieces collectively called glass aggregate product. The aggregate fell into a hopper at the bottom of the quench tank. The hopper was attached to a screw conveyor, which lifted the aggregate out of the quench tank and dropped it into 55-gallon drums. The water level in the tank was maintained by a float valve that allowed water into the tank as the level was reduced.

The quench tank was sampled from a valve installed on the tank drain. A 1-liter grab sample was collected every half hour over the same 6-hour period, during which the glass aggregate was sampled. Grab samples were composited in a large, glass container, which was mixed upon collection of all grab samples. Samples for laboratory analysis were collected by pouring the composited quench tank water into laboratory sample containers. Quench-tank water was analyzed for PCBs, metals, and SVOCs.

**TABLE 4-8
POST-CARBON GAS SAMPLE RESULTS**

Analyte	Sample Identification		
PCBs (Method 680) (ng/dscm)	Run #1	Run #2	Run #3
1-MoCB	1.18	<0.232	<0.0650
(4)-DiCB	4.09	0.781	<0.0650
(7)-DiCB	0.468	<0.232	<0.0650
(6)-DiCB	8.08	1.60	<0.226
(5)-DiCB	<0.246	2.02	<0.0650
8-DiCB	8.87	1.97	0.322
(19)-TriCB	0.863	<0.232	<0.0650
18,(30)-TriCB	8.92	2.41	0.362
(17)-TriCB	3.97	1.04	1.49
(27)-TriCB	0.722	<0.232	<0.0650
(24)-TriCB	1.68	0.505	0.0839
(26,29)-TriCB	3.38	<0.971	<0.133
(25)-TriCB	2.39	0.608	<0.0878
31-TriCB	6.51	2.06	<0.345
(20),28-TriCB	6.80	2.18	<0.371
(21),33-TriCB	1.40	0.651	0.147
22-TriCB	1.67	0.580	0.113
37-TriCB	0.488	0.269	<0.0650
(50,53)-TeCB	0.927	0.334	<0.0650
(45,51)-TeCB	1.34	0.468	0.0696
(46)-TeCB	0.355	<0.232	<0.0650
52-TeCB	3.43	<1.35	<0.248
49,(69)-TeCB	2.28	0.962	0.141
(48)-TeCB	0.365	<0.232	<0.0650
44,47,(65)-TeCB	3.28	1.40	<0.224
(59,62,75)-TeCB	0.419	<0.232	<0.0650
(40,71)-TeCB	1.90	0.941	0.125
64-TeCB	1.10	0.508	0.0800
(61),70,74,(76)-TeCB	1.21	0.679	0.159
66-TeCB	0.628	0.366	0.0891
56 TeCB	1.11	0.777	0.117
90,101,(113)-PeCB	0.589	0.267	<0.0650
86,87,97,(108),119,(125)- PeCB	<0.246	0.311	<0.0650
(85,116)-PeCB	0.579	0.327	<0.0650
118-PeCB	0.271	<0.232	<0.0650
158-HxCB	0.261	<0.232	<0.0650
Metals (µg/dscm)	Run #1	Run #2	Run #3
Arsenic	<1,410	<1,390	<1,340
Barium	<141	<150	<134
Cadmium	<141	<139	<134
Chromium (Total)	<281	<279	<268

**TABLE 4-8
POST-CARBON GAS SAMPLE RESULTS**

Analyte	Sample Identification		
Metals (µg/dscm) (Continued)	Run #1	Run #2	Run #3
Lead	<1,410	<1,390	<1,340
Mercury	<1.46	<2.32	<1.04
Selenium	<1,410	<1,390	<1,340
Silver	<141	<139	<134
PCDDs/PCDFs (Method 8290) (ng/dscm)	Run #1	Run #2	Run #3
2,3,7,8-TCDD	<0.00232	<0.00705	<0.00302
1,2,3,7,8-PeCDD	<0.00185	<0.00199	<0.00141
1,2,3,4,7,8-HxCDD	0.00212 EMPC	<0.00223	<0.00166
1,2,3,6,7,8-HxCDD	<0.00286	<0.00283	<0.0272
1,2,3,7,8,9-HxCDD	<0.00180	0.00121	<0.00156
1,2,3,4,6,7,8-HpCDD	<0.00872	<0.0121	<0.0832
OCDD	<0.0451	<0.0399	<0.0317
2,3,7,8-TCDF	0.00532	<0.00118	<0.00205
1,2,3,7,8-PeCDF	<0.00759	<0.00278	<0.000966
2,3,4,7,8-PeCDF	<0.00335	<0.00274	<0.000941
1,2,3,4,7,8-HxCDF	<0.00912	<0.00626	<0.00116
1,2,3,6,7,8-HxCDF	<0.00409	<0.00325	<0.00109
2,3,4,6,7,8-HxCDF	<0.00148	<0.000904	<0.00121
1,2,3,7,8,9-HxCDF	<0.00163	<0.000997	<0.00134
1,2,3,4,6,7,8-HpCDF	<0.0090	<0.00427	<0.0253
1,2,3,4,7,8,9-HpCDF	<0.00207	<0.00146	<0.00171
OCDF	0.0124	<0.00366	<0.00317
SVOCs (ng/dscm)	Run #1	Run #2	Run #3
Benzoic Acid	<3,220	25,900	6,410

Notes

µg/dscm = Microgram per dry standard cubic meter

ng/dscm = Nanogram per dry standard cubic meter

PCBs - Polychlorinated biphenyls

PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

SVOCs - Semivolatile organic compounds

EMPC = Estimated Maximum Possible Concentration.

PCB and PCDD/PCDF congeners, SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

PCBs

Quench water was analyzed for PCB content to determine whether, as a waste stream, the quench water had acquired PCBs from the molten sediment. Quench-water samples were analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by high-resolution EPA Method 1668 (EPA 1997). Results of the PCB analysis were used in the evaluation of Primary Objective P1, and are reported in Table 4-9.

Total PCBs, calculated by summing the concentration of homologs, ranged from less than 0.500 to 1.09 nanograms per liter (ng/L) (0.5×10^{-6} to 1.09×10^{-6} ppm].

Metals

Quench-tank-water composite samples were analyzed for RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in the glass aggregate product are detailed in Table 4-9.

All of the quench-tank-water samples exhibited minor detections of barium, but all other metals were below detection limits.

SVOCs

Four samples of the quench-tank water were collected and submitted for analysis of SVOCs. The resulting SVOC concentrations, analyzed by EPA Method 8270C (EPA 1996), are summarized in Table 4-9. Only one detection of a single SVOC, di-n-octylphthalate, was observed in sample M-QW-02. Phthalates are sometimes considered to be common laboratory or sampling contaminants.

**TABLE 4-9
QUENCH WATER COMPOSITE SAMPLE RESULTS**

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	M-QW-01	M-QW-02	M-QW-03	M-QW-04	M-QW-05	M-QW-06
8-DiCB	<0.500	0.513	<0.500	<0.500	<0.500	<0.500
18,(30)-TriCB	0.563	0.575	<0.500	0.539	<0.500	<0.500
Total PCBs (homolog sum) (pg/g)	0.563	1.09	<0.500	0.539	<0.500	<0.500
Metals (mg/L)						
Arsenic	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	0.029	0.035	0.031	0.03	<0.01	<0.01
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SVOCs (µg/L)						
Di-n-octylphthalate	<5.0	21 J	<5.0	<5.3	--	--
Total SVOCs	<5.0	21 J	<5.0	<5.3	--	--

Notes:

mg/L = Milligram per liter

pg/g = Picogram per gram

µg/L = Microgram per liter

PCBs - Polychlorinated biphenyls

PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

SVOCs - Semivolatile organic compounds

-- Not sampled

J = Estimated Value, Concentration Below Lower Calibration Range.

PCB congeners and SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Samples were not analyzed for PCDDs/PCDFs or VOCs.

4.3.2.7 Cooling-Tower Discharge

As previously described, a water-cooled air sampling probe was inserted into the melter flue to extract a portion of the melter flue gas for sampling. The temperature of the flue gas was reduced to 190°C (400° F) for sampling. After sampling, the flue gas was further cooled using a cooling tower before it passed through carbon treatment. Because the melter was fired by natural gas, it was expected that the cooling tower would generate water as the flue gas cooled and that it would need to be drained periodically. In practice, the cooling water in the loop quickly became acidic and degraded parts in the recirculating pump. The system then was converted to a non-recirculating system, wherein fresh water entered the cooling tower and was discharged to a drain.

Cooling-tower samples were collected from the drain during the second, fourth, and sixth sampling runs. During the second sampling run, the cooling-tower system was configured as a recirculating loop, and any contaminants in the water in the system were expected to be more concentrated. During the fourth and sixth sampling runs, the system was configured with fresh water, so the contaminants in the water were expected to be more dilute. Cooling-tower-water samples were submitted to a laboratory for analysis of PCBs, metals, and SVOCs. The samples were grab samples and were not collected over time for compositing.

PCBs

Cooling-tower water was analyzed for PCB content to determine whether, as a waste stream, the cooling tower water had acquired PCBs from the melter flue gas. Cooling-tower water samples were analyzed for both the Wisconsin State Laboratory of Hygiene list of PCB congeners and total PCBs by high-resolution EPA Method 1668 (EPA 1997). The results of the PCB analyses were used in the evaluation of Primary Objective P1, and PCB results reported in Table 4-10.

Total PCBs, calculated by summing the concentration of homologs, in the cooling-tower-water samples ranged from less than 0.500 to 7.78 ng/L (5.00×10^{-7} to 7.78×10^{-6} ppm). The total PCB concentration in sample M-CTD-02 was higher than those in other samples. Sample M-CTD-02 was collected while the cooling tower was configured as a recirculating loop, and the water in the cooling tower was expected to exhibit higher concentrations than water after it was converted to use fresh water.

**TABLE 4-10
COOLING-TOWER-WATER SAMPLE RESULTS**

Analyte	Sample Identification		
	M-CTD-02	M-CTD-04	M-CTD-06
PCBs (Method 1668)			
(pg/g)			
8-DiCB	0.607	<0.500	<0.500
18,(30)-TriCB	0.788	<0.500	<0.500
(26,29)-TriCB	0.712	<0.500	<0.500
31-TriCB	1.45	<0.500	<0.500
(20),28-TriCB	1.46	<0.500	<0.500
52-TeCB	1.10	<0.500	0.515
49,(69)-TeCB	0.635	<0.500	<0.500
44,47,(65)-TeCB	1.03	<0.500	<0.500
Total PCBs (all congeners)	7.78	<0.500	0.515
Total PCBs (homolog sum)			
(pg/g)			
Metals (mg/L)			
Arsenic	0.65	<0.10	<0.10
Barium	0.082	0.026	<0.01
Cadmium	0.079	<0.01	<0.01
Chromium	3.5	0.033	<0.02
Mercury	0.12	0.0045	<0.0002
Lead	5.9	0.25	<0.10
Selenium	<2.5	<0.10	<0.10
Silver	<0.02	<0.01	<0.01

Notes:

mg/L = Milligram per liter

pg/g = Picogram per gram

PCBs = Polychlorinated biphenyls

PCDDs/PCDFs = Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

-- Not sampled

PCB congeners and SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Samples were not analyzed for PCDDs/PCDFs or VOCs.

Metals

Cooling-tower-water samples were analyzed for the eight RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in the cooling-tower water are shown in Table 4-10.

As expected, metal concentrations in the initial sample (M-CTD-02) were higher than concentrations in subsequent samples.

SVOCs

Two samples of the cooling-tower water were collected and submitted for analysis of SVOCs by Method 8270C (EPA 1996). No SVOCs were detected in either of the two samples.

4.3.2.8 Dust

As the demonstration began and air sampling proceeded, it became apparent that the air sampling probe was becoming clogged by solids in the melter flue gas as it rapidly cooled from 1600°C to 190°C (2900°F to 400°F). Solids accumulated in the probe until the gas would no longer flow, and sampling became difficult. Sampling was halted, and the probe was removed from the furnace and cleaned. The solid material, which apparently consisted of accumulated dust, was collected as the probe was cleaned and weighed. The accumulated dust was composited daily, so three composite samples of dust were obtained over the course of the demonstration.

The dust material was brown in color and consisted of some large pieces, so it was crushed with a mechanical crusher so it could be inserted into laboratory sample containers. Dust samples were submitted to a laboratory and analyzed for metals and dioxins and furans.

Minergy claims that the dust issues encountered during the demonstration would be controlled in a commercial scale operation.

Metals

Dust samples were analyzed for RCRA metals by EPA Methods 6010B/7471A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in the dust-composite samples are detailed in Table 4-11.

Several metals were present at elevated levels. Metals concentrations in each of the dust composites were similar in magnitude.

Dioxins and Furans

The dust material was sampled to determine whether dioxins and furans were present. The material was analyzed for dioxins and furans by EPA Method 8290 (EPA 1996), and the laboratory provided results for individual congeners and total dioxins and furans, based on summing the homologs. Results of the dioxins and furans analysis are summarized in Table 4-11.

The table shows that the dust contained total dioxin and furan concentrations ranging from below detection limits (<0.327) to 10.1 ng/g ($<3.27 \times 10^{-7}$ to 1.01×10^{-5} ppm).

4.3.2.9 Leachates of Glass Aggregate Product and Crushed Glass Aggregate Product

The glass aggregate product was subjected to two water-leach tests: the ASTM Standard Test Method for Shake Extraction of Solid Waste with Water (D3987-99) (ASTM 1999) and the Synthetic Precipitate Leaching Procedure (SPLP) (EPA Method 1312) (EPA 1996). The glass aggregate product was extracted by the ASTM water leach method and analyzed for PCBs and metals. Glass-aggregate-product samples also were extracted by the SPLP method and analyzed for PCBs, metals, dioxins and furans, and SVOCs. Results of total PCBs and metals analysis of the leachates were used to evaluate Primary Objective P2, and the results are summarized in Table 4-12.

**TABLE 4-11
DUST COMPOSITE SAMPLE RESULTS**

Analyte	Sample Identification		
	M-AS-01	M-AS-02	M-AS-03
Metals (mg/kg)			
Arsenic	87	120	130
Barium	230	210	210
Cadmium	12	18	19
Chromium	190	250	240
Mercury	0.50	0.61	1.0
Lead	760	1,100	1,200
Selenium	44	40	43
Silver	4.7	7.1	8.1
PCDDs/PCDFs (Method 8290) (µg/g)			
1,2,3,7,8-PeCDF	<0.334	<0.430	0.636
2,3,4,7,8-PeCDF	<0.327	<0.420	0.771
1,2,3,4,7,8-HxCDF	<0.548	<0.480	0.585
1,2,3,4,6,7,8-HpCDF	<0.831	<0.748	0.871
Total PCDDs/PCDFs (homolog sum) (pg/g)	<0.327	<0.420	10.1

Notes:

mg/kg = Milligram per kilogram

pg/kg = Picogram per kilogram

PCDDs/PCDFs - Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

PCDD/PCDF congeners less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Samples were not analyzed for PCBs, SVOCs or VOCs.

TABLE 4-12
GLASS AGGREGATE PRODUCT ASTM LEACHATE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	M-G-01	M-G-02	M-G-03	M-G-04	M-G-05	M-G-06
Total PCBs (homolog sum) (pg/g)	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Metals (mg/L)						
Arsenic	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Notes:

pg/g = Picogram per gram

mg/L = Milligram per liter

PCBs = Polychlorinated biphenyls

PCB congeners less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Samples were not analyzed for PCDDs/PCDFs, SVOCs or VOCs

Portions of the glass aggregate product were crushed and screened through a 200-mesh (75-micron, 0.003-inch) sieve at the University of Wisconsin at Platteville Engineering Department laboratory. Glass aggregate product samples had to be air-dried before crushing, so they were laid out in disposable aluminum pans in front of fans. Some of the pans were placed in drying ovens and set on circulating air only. After drying, the glass aggregate product was transferred to a rotating drum crusher that contained several steel balls of various sizes. The drum crusher (Soiltest Model M-501) was cleaned between each sample, and a sand blank was crushed and collected before each sample was placed in the crusher. The crushed glass was then transferred to sieves and shaken to separate the finely ground glass particles. Fine particles that passed the 200-mesh sieve were collected, extracted by SPLP methods, and analyzed for PCBs, metals, and SVOCs.

4.3.2.9.1 Glass Aggregate Product ASTM Water-Leach Test

Portions of the glass aggregate product samples collected from the six sampling runs were extracted by the ASIM water-leaching procedure (ASIM 1999) before analysis for PCBs and metals. Results of the extract analysis were used in the evaluation of Primary Objective P2 to determine the material's potential for beneficial reuse.

PCBs

PCBs were analyzed by high-resolution EPA Method 1668 (EPA 1997), and individual congeners and total PCBs were reported by the laboratory. Results of the ASTM extraction and PCB analyses are summarized in Table 4-12. The table shows that there were no detections of PCBs in any of the six sampling runs.

Metals

Glass aggregate product ASTM water leach samples were analyzed for RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in glass aggregate leachates are detailed in Table 4-12.

Metals concentrations in ASTM-leachate samples are below detections limits for all metals analyzed.

4.3.2.9.2 Glass Aggregate Product SPLP Leach Test

Glass aggregate product composite samples also were extracted using SPLP (EPA 1996) and analyzed for PCBs, metals, dioxins and furans, and SVOCs. SPLP was designed to mimic rainwater leaching contaminants from a material and potentially migrating into groundwater. SPLP generally is used to more closely simulate actual rainwater leaching effects, rather than landfill leaching effects. The sample extract was analyzed for PCBs, metals, and dioxins and furans.

PCBs

After SPLP extraction, PCBs were analyzed by high resolution EPA Method 1668 (EPA 1997), with total PCBs and individual congeners reported by the laboratory. Results of the laboratory analysis are detailed in Table 4-13.

Results of the PCB analysis exhibited no detections of PCB congeners in any of the glass aggregate product samples.

Metals

Glass aggregate product SPLP leachate samples were analyzed for RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in the glass aggregate product leachates are summarized in Table 4-13.

No detections of any of the metals analyzed were exhibited in any of the glass aggregate product sample leachates.

Dioxins and Furans

Glass aggregate product SPLP-leachate samples were analyzed for dioxins and furans by EPA Method 8290 (EPA 1996), and the laboratory provided results for individual compounds and total dioxins and furans. Results of the dioxins and furans analysis are summarized in Table 4-13.

As shown, the leachate was observed to contain total dioxins and furans concentrations ranging from 0.0332 to 0.615 ng/L (3.33×10^{-8} to 6.15×10^{-7} ppm).

**TABLE 4-13
GLASS AGGREGATE PRODUCT SPLP LEACHATE SAMPLE RESULTS**

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	M-G-01	M-G-02	M-G-03	M-G-04	M-G-05	M-G-06
Total PCBs (homolog sum) (pg/g)	<0.562	<0.588	<0.61	<0.633	<0.725	<0.694
Metals (mg/L)						
Arsenic	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCDDs/PCDFs (Method 8290) (pg/g)						
OCDD	0.387	<0.0445	<0.0377	<0.0323	<0.0261	<0.0310
1,2,3,4,6,7,8-HpCDF	0.0061	<0.0025	<0.0030	<0.0027	<0.0024	<0.0023
Total PCDD/Fs (homolog sum)	0.596	0.0615	0.0532	0.0385	0.0332	0.0435

Notes:

pg/g = Picogram per gram

mg/L = Milligram per liter

PCBs = Polychlorinated biphenyls

PCDDs/PCDFs = Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans

-- Not sampled

PCB and PCDD/PCDF congeners, and SVOCs less than detection limits in all samples are not included in this table.

For a complete list of these analytes, see Appendix A.

Samples were not analyzed for VOCs.

SVOCs

Four of the six glass aggregate product composite samples were submitted for SPLP extraction and SVOC analysis by EPA Method 8270C (EPA 1996). Total SVOC concentrations in SPLP-leachate samples are below detections limits for all SVOCs analyzed.

4.3.2.9.3 Crushed Glass Aggregate Product SPLP-Leach Test

Portions of the glass aggregate product composite samples were crushed and screened through a 200-mesh (75-micron, 0.003-inch) sieve. The crushed glass aggregate product was then transferred to sieves and shaken to separate the finely ground glass particles. The fine particles that passed the 200-mesh sieve were collected and submitted to a laboratory for SPLP extraction and analysis of PCBs, metals, and SVOCs.

PCBs

After the crushed glass aggregate product was subjected to SPLP extraction, PCBs were analyzed by high-resolution EPA Method 1668, with total PCBs and individual congeners reported by the laboratory. Results of the laboratory analysis are detailed in Table 4-14.

Results of the PCD analysis exhibited no detections of PCDs in any of the glass aggregate product composite samples.

Metals

Crushed glass aggregate product SPLP-leachate samples were analyzed for RCRA metals by EPA Methods 6010B/7470A (EPA 1996). Individual metals analyzed and their resulting concentrations observed in glass aggregate leachates are detailed in Table 4-14.

No metals were detected in any of the glass aggregate product composite sample leachates.

TABLE 4-14
CRUSHED GLASS AGGREGATE SPLP LEACHATE SAMPLE RESULTS

Analyte	Sample Identification					
PCBs (Method 1668) (pg/g)	M-CG-01	M-CG-02	M-CG-03	M-CG-04	M-CG-05	M-CG-06
Total PCBs (homolog sum) (pg/g)	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Metals (mg/L)						
Arsenic	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Barium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Selenium	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
SVOCs (µg/L)						
Bis(2-ethylhexyl)phthalate	<5.0	--	<5.0	<5.0	--	14 J
Total SVOCs	<5.0	--	<5.0	<5.0	--	14 J

Notes:

pg/g = Picogram per gram

mg/L = Milligram per liter

µg/L = Microgram per liter

PCBs = Polychlorinated biphenyls

SVOCs = Semivolatile organic compounds

J = Estimated Value, Concentration Below Lower Calibration Range.

-- Not sampled

PCB congeners and SVOCs less than detection limits in all samples are not included in this table. For a complete list of these analytes, see Appendix A.

Samples were not analyzed for PCDDs/PCDFs or VOCs.

SVOCs

Glass aggregate product SPLP-leachate samples were analyzed for SVOCs by EPA Method 8270C (EPA 1996). The resulting concentrations expressed as total SVOCs observed in the glass aggregate product leachates are summarized in Table 4-14.

Only one SVOC (bis[2-ethylhexyl]phthalate) was detected in one of the four SPLP-leachate crushed glass aggregate product samples (M-CG-06). SVOC concentrations in SPLP-leachate samples were below detections limits for the other three crushed glass aggregate product samples analyzed.

4.3.3 SITE Demonstration Objectives

The main component of the Minergy GFT is an oxygen/fuel-fired melter that operates at a temperature of 1,600 °C (2,900 °F). The technology can be used to vitrify PCB-contaminated sediments as well as sediments containing metal contamination. When the molten glass is cooled, a glass aggregate is formed. The product has potential economic value as a concrete aggregate, roadbed fill, or other construction material.

The purpose of the SITE demonstration of the Minergy GFT technology was to provide an unbiased, quantitative evaluation of the effectiveness and cost of this technology. To ensure the collection of data that would allow such an evaluation, specific, performance-based objectives were developed. The two primary objectives are considered to be critical for the technology evaluation. Secondary objectives provide additional information that is useful but not critical. The following sections provide an evaluation of the primary and secondary objectives.

4.3.3.1 Primary Objectives Evaluation

The following primary objectives (P) are considered to be critical to the success of the SITE evaluation. For each objective, a brief description of the experimental approach is given.

P1 Determine the treatment efficiency (TE) of PCBs in dredged-and-dewatered river sediment when processed in the Minergy GFT.

The concentration of PCBs in river sediment, the glass aggregate product and all the waste streams were analyzed. The TE calculation for the GFT consisted of a comparison of the PCB content of the six composite samples of the dredged-and-dewatered sediment versus PCB concentrations of all other process outputs, including six composite samples of the glass aggregate product, quench water, and three

composite samples of the cooling-tower discharge. Based on the sampling methodology, the six flue-gas samples were discrete samples, not composite samples.

The TE of the GFT process was calculated as follows:

$$TE = (W_{in} - W_{out}) / W_{in} \times 100\%$$

Where:

W_{in} = Geometric mean of PCB input concentration:
For the GFT process, W_{in} represents the PCB concentration of the dredged-and-dewatered sediment; for the melting system only, W_{in} represents the PCB concentration of the drum-dried sediment.

W_{out} = Geometric mean of PCB output concentration:
For the GFT process, W_{out} represents the combined PCB concentrations of the process flue gas stream, the quench water stream, and the glass aggregate product.

A TE for the Holoflute[®] dryer demonstration could not be calculated due to the sediment carry-over into all waste streams and data incompatibility. Data collected during the Holoflute[®] dryer test were not used to determine a TE for the GFT because of the incompatibility of the PCB congener lists analyzed for the dryer and melter evaluations. The TE for the GFT was calculated using data obtained from sampling dredged-and-dewatered sediment from roll-off boxes. This calculation provides a TE for the technology as demonstrated by Minergy. Table 4-13 provides the geometric means of the input and output PCB data. The TE for the GFT process was calculated to be 99.9995 percent.¹

A removal efficiency (RE) was calculated for the melter phase only of the GFT, because of the uncertainties associated with the drum dryer used to dry the bulk of the demonstration sediment. Only sediment entering and exiting the drum dryer were sampled, and samples of dryer exhaust gas or condensate were not collectable based on the dryer setup.

Minergy claims that commercial GFT units will condense all water vapor from the dryer vent and send it to the dredging wastewater treatment operation while non-condensable gases will be recycled to the melter.

The melter RE consisted of a comparison of six composite samples of dried and prepared sediment entering the furnace versus PCB concentrations of all other furnace outputs, including composite samples of glass aggregate, quench water, furnace flue gas, and cooling tower discharge water. The RE

¹ The treatment efficiency was calculated two ways: ND – MDL, the TE = 99.9994%; for ND – ½ MDL, the TE = 99.9995%.

calculation provides a measure of the efficiency of the melter furnace only. Minergy proposes that the final design of a full-scale GFT system will route all dryer output streams into the melter furnace. The RE for the melter phase only of the GFT was calculated to be 99.9995 percent.

P2 Determine whether the GFT glass aggregate product meets the criteria for beneficial reuse under relevant federal and state regulations. The aggregate product will be judged to be beneficial with respect to each metal or PCB if the 95 percent upper confidence limit (UCL₉₅) for the estimated mean (of each metal or PCB) is less than federal or state regulatory requirements, as applicable.

The final glass aggregate product from the GFT demonstration was subjected to SPLP and ASTM extractions. Aqueous extraction procedures were followed by analysis of the extracts for metals and PCBs. The results of these tests were evaluated against federal and state requirements to determine if the glass aggregate product is suitable for beneficial reuse. No federal criteria were found for evaluation of the glass material for beneficial reuse; however, the state of Wisconsin has promulgated a regulation with criteria for the use of industrial by-products. Results of the analyses on the extracts, as well as total contaminants in the glass aggregate product, were evaluated against Wisconsin Administrative Code Chapters NR 538 (NR 538) and NR140 (NR140) criteria. (WDNR 1997).

The purpose of Wisconsin's NR 538 regulation (WDNR 1997) is to allow and encourage the beneficial reuse of industrial by-products to preserve resources, conserve energy, and reduce or eliminate the need to dispose of industrial by-products in landfills. The regulation contains criteria for five categories of industrial by-products, the uses for which depend upon which criteria category the material meets. The categories dictate how the material can be used and become more restrictive as the criteria become less strict. The extent of allowable uses for the evaluated material (glass aggregate product) diminishes as the category numbers rise from one to five. Based on a chemical analysis of the glass aggregate product compared to the criteria in NR 538, the glass aggregate product qualifies for beneficial reuse under NR 538 Category 2 criteria. Under this category, the glass aggregate product qualifies for beneficial reuse as any of those products or uses described in the rule as Category 2 and may be subject to notification requirements.

TABLE 4-15
INPUT AND OUTPUT PCB CONCENTRATIONS

Feed or Waste Stream	Geometric Mean of Total PCBs in Samples (parts per million)
Dredged-and-Dewatered Sediment	28.8
Drum-Dried Sediment	22.4
Sediment Entering Melter	27.8
Glass Aggregate Product	1.37×10^{-4}
Flue Gas	3.51×10^{-6}
Quench Water	4.16×10^{-7}
Cooling-Tower Discharge Water	1.26×10^{-6}

Notes: When calculating the geometric mean non-detects were assigned a value of ½ the method detection limit.

Geometric Mean is calculated as $GM_y = \sqrt[n]{y_1, y_2, y_3, \dots, y_n}$

Material evaluation under Category 1 criteria is subject to strict standards, some of which are lower than current method detection limits. Category 2 criteria, while less stringent, still require low contaminant concentrations derived from total solid and ASTM water-leach analyses. Materials qualifying for beneficial reuse under Category 2 criteria are subject to monitoring and to regulatory and property owner notification requirements. A copy of Chapter NR 538 Wisconsin Administrative Code is provided in Appendix D.

Table 4-14 presents the post-demonstration glass aggregate product sample results compared to the NR 538 Category 2 criteria for both water-leach tests (SPLP and ASTM), for Total Elements Analysis (WDNR 1997), and for NR140 groundwater quality criteria (WDNR 2001). EPA's evaluation of the GFT product included water leach tests of the glass aggregate product, as well as the crushed glass aggregate product that passed through a 200-mesh (75-micron, 0.003 inch) sieve.

**TABLE 4-16
BENEFICIAL REUSE RESULTS AND CRITERIA**

Contaminant	Glass Aggregate Product ASTM ^a Leachate Concentration (mg/L) ^b	NR 538/NR140 ^c Category 2 Criteria for Water Leach Tests (mg/L)	Total Elements Analysis Results for Glass Aggregate (mg/kg) ^d	NR 538 Category 2 Criteria for Total Elements Analysis (mg/kg)	Glass Aggregate Product SPLP ^e Leachate Concentration (mg/L)
Total PCBs ^f	<5.00 x 10 ⁻⁷	0.000003 ^g	0.00092	- ^h	<6.35 x 10 ⁻⁷
Arsenic	<0.10 ⁱ	0.05	5.1	21	<0.10
Barium	<0.010	4.0	341	-	<0.010
Cadmium	<0.010	0.005	0.51	-	<0.010
Chromium	<0.020	0.10	52	-	<0.020
Lead	<0.10	0.015	16	-	<0.10
Mercury	<0.00020	0.002	0.26	-	<0.00020
Selenium	<0.10	0.10	8.9	-	<0.10
Silver	<0.010	0.10	3.2		<0.010

- Note: a ASTM = American Society for Testing and Materials
b mg/L = Milligram per liter
c NR538/NR140 = Wisconsin Administrative Code Chapters NR 538 and NR 140
d mg/kg = Milligram per kilogram
The Total Elements Analysis Results for Glass Aggregate are derived from the glass-aggregate-composite-sample results. These values are the 95% upper confidence bound (UCB) of the arithmetic mean of the glass aggregate results. The 95% UCBs for arsenic, cadmium, and mercury are calculated from method detection limits. The methods used for the calculation of the 95 % UCB are detailed in the QAPP Section 3.2.
e SPLP = Synthetic Precipitate Leaching Procedure. SPLP analysis results are not compared to NR 538 Category 2 criteria.
f PCBs = Polychlorinated biphenyls
g NR 538 does not contain criteria for total PCBs. The criteria for comparison is NR 140, Groundwater Quality Standards Preventive Action Limit
h - Criteria do not exist
i < less than

As shown in Table 4-14, the glass aggregate product meets the Wisconsin NR 538 beneficial reuse criteria for Category 2 with the possible exception of arsenic and cadmium. The NR 538 water leachate criteria for arsenic and cadmium are lower than the detection limits for each of these elements.

4.3.3.2 Secondary Objectives Evaluation

The following secondary objectives are not considered critical to the success of the evaluation but may offer additional information on the innovative technology. For each objective, a brief description of the experimental approach is given.

S1 Determine the unit cost of operating the GFT on dredged-and-dewatered river sediment.

The unit cost of removing PCBs and organic and inorganic contaminants from river sediment were determined based on data provided by Minergy. This secondary objective was achieved by assessing twelve expense categories.

Capital and operating costs were estimated for conducting a full-scale operation of the GFT. A detailed discussion of costs is included in Section 3.0 of this report. The NPV of the facility described in this document was estimated at \$122,041,000. The estimated cost per ton to treat the sediments is \$38.74 per ton.

S2 Quantify the organic and inorganic contaminant losses from the existing or alternative drying process used to dry the dredged-and-dewatered river sediment.

The sampling plan for the dryer demonstration was designed to permit the quantification of organic and inorganic content before and after the drying process. However, the small scale of the demonstration and the carryover of dust from the dryer into the condensate and gas streams gave rise to ambiguous results. As explained in Section 4.2.1.1, the Holoflite® dryer process evaluation had critical flaws, which prevented proper evaluation of contaminant losses. The results of the PCB analyses were based on a limited list of congeners and are not comparable to PCB analyses performed after the dryer demonstration. The list of congeners was based on a small number of congeners (about 25) that were considered to be among the most toxic PCB constituents, but these congeners were not necessarily present in the PCBs used by the paper industry or found in the sediment used in the GFT demonstration. The evaluation of the Secondary Objective S2 was not completed because of these differences. Analytical results of samples collected during the Holoflite® dryer demonstration are presented in Appendix C.

Also, because the carryover of dust into the condensate and dryer gas streams resulted in suspect results, inorganic contaminant losses were not characterized for the dryer.

S3 Characterize the organic and inorganic constituents in all GFT process input and output streams.

Secondary Objective S3 was intended to combine data from all the input and output streams of the GFT process and characterizes the results. As noted in Section 1.0, the GFT process consists of a drying phase and a melting phase. Input streams include: dredged-and-dewatered sediment, dried sediment, flux, and city water. Output streams include: dried sediment, dryer gas, dryer condensate, glass aggregate, furnace gas, quench tank water, cooling tower discharge water, and accumulated dust. These input and output streams were analyzed for some or all of the following analytes: PCBs, dioxins and furans, metals, SVOCs, VOCs, and HCl/Cl₂. VOC analysis was conducted on both pre- and post- melter samples to evaluate the potential production of VOCs in the melting process.

Analytical results of the samples collected from all input and output streams, which were presented in Section 4.3 through 4.3.2.8, were evaluated for this objective. This objective consisted mainly of review and presentation of analytical results from the demonstration, and not an interpretation. Analytical results from the melter demonstration were presented in Tables 4-2 through 4-12, while Holoflite® dryer demonstration results are presented in Appendix C.

As in Secondary Objective S2, Analytical results of all of the samples collected during both the pilot-scale dryer test and the melter test were evaluated in a similar manner as those used to obtain Primary Objective P1. The UCL₉₅ were calculated with the same formula described in Primary Objective P2. This objective consisted mainly of a review of analytical results from the demonstration and not an interpretation.

Results of the Holoflite® dryer test are presented in Appendix C. Analytical results of dredged-and-dewatered sediment samples collected from the roll-off boxes and drum-dried sediment samples collected from the supersacks at the Minergy facility in Winneconne, Wisconsin, were detailed previously in Tables 4-2 and 4-3, respectively.

Melter samples were collected during the demonstration in August 2001, results of which were presented in Section 4.3.2.

4.4 DATA QUALITY

Data and analytical results from 94 percent (191 samples) of the 203 samples analyzed in support of the GFT demonstration were reviewed for quality, usability, and evaluation of the primary objectives. Data validation was performed on PCBs, metals, dioxins and furans, SVOCs, VOCs, and hydrogen chloride/chlorine results. This validation was based on a review of the QC results, which included surrogate recoveries; laboratory control samples (LCS) and laboratory control sample duplicates (LCSD); matrix spikes (MS) and matrix spike duplicates (MSD); and field, equipment, and method blanks. The following paragraphs briefly summarize the results of the QC analyses; more detailed information is provided in the TER.

4.4.1 Surrogate Recoveries

Surrogates are compounds of known concentrations added to each sample to evaluate the effectiveness of the analysis in measuring organic contaminants that may be present in the sample. The analytical results of surrogate compounds in samples analyzed by the laboratories were found to be within acceptable limits, except in the samples described below.

Most of the problems with surrogate recoveries were observed in the SVOC analyses. Several samples had low or no surrogate recoveries, indicating a possible low bias for associated sample results. The acid surrogate 2,4,6-tribromophenol was not recovered in any of the dried melter feed samples (M-S-01, -02, -03, -04, and -03D). Additionally, the recoveries for two other acid surrogates, 2-fluorophenol and phenol-d5, were low for samples M-S-03, M-S-03D, and M-S-04. All phenol results for the dried melter feed samples were nondetect but were qualified as invalid (IS) because of poor surrogate recoveries. Therefore, the SVOC results for these samples were qualified as IS. The percent recoveries of all SVOC analytes in the MS and MSD sample (M-G-03), which was designated as the soil MD/MSD sample, were within QC limits with the exception of N-nitrosodimethylamine for which the recovery was below the lower QC limit of 40 percent. The non-detect result for this analyte has been qualified as estimated nondetect (UJ), because of the likely low bias. Although there could have been a negative bias in the phenol and single N-nitrosodimethylamine results, when calculating total SVOCs in these samples, all these results were assumed to be below their detection limits. Discrepancies were observed for the SVOC duplicate analysis on sample M-S-03. The results for the analysis of the primary sample showed the presence of seven polynuclear aromatic hydrocarbons (PAHs), ranging in concentration from 190 ug/kg for benzo(k)fluoranthene to 340 ug/kg for benzo(b)fluoranthene. The results for all these PAHs were

reported as nondetect for the analysis of the duplicate sample M-S-03D. The discrepancy reflects, most likely, nonhomogeneous sample matrix. The concentrations of the 7 PAHs reported in sample M-S-03, therefore, are qualified as estimated values based on the uncertainty of the overall precision of sampling and analytical procedures.

Some minor problems, such as low recoveries and out of calibration range results, were observed with surrogate recoveries in VOC analyses that did not warrant qualifications. For samples M-S-03, M-S-04, and M-S-04D the recovery of VOC surrogate dibromofluoromethane, at less than 10 percent for each sample, was unacceptable. In addition, for sample M-S-04D, the recoveries of 1,2-dichloroethane and 4-bromofluorobenzene were marginally biased high. No data, however, were impacted for samples M-S-03 and M-S-03D for VOC analysis, because out-of-control recovery of one surrogate is acceptable. For sample M-S-04D, all analytes associated with these two surrogates were nondetect in the sample. No data, therefore, were qualified based on the high recoveries of the two surrogates.

4.4.2 Laboratory Control Sample/Laboratory Control Sample Duplicate

An LCS is a blank sample consisting of laboratory-grade water with method-appropriate reagents, spiked with known concentrations of target analytes and analyzed in exactly the same way as field samples. Recovered concentrations of spiked analytes are then determined as percent recoveries (%R), which are used to evaluate the precision and accuracy of the analytical procedure.

Recoveries for LCSs and LCSDs analyzed for SVOCs were within QC limits, with the following exceptions. Two compounds were found to be out of control limits, and their associated non-detect (ND) results were qualified as estimated (UJ). The non-detect results for 4,6-dinitro-2-methylphenol, 2,4-dinitrophenol, and pentachlorophenol were qualified as invalid (IV) for both flue gas samples because of the possible extremely low bias in their recoveries during analysis, and these samples are not included in the ITER. It is important to note that SVOCs are reported as total SVOCs in the ITER.

In general, LCSs and LCSDs analyzed for metals were within laboratory control limits, and no data were qualified as a result. Dioxins and furans control samples were analyzed within limits.

4.4.3 Matrix Spike/Matrix Spike Duplicate

MS/MSDs are field samples that are used to determine the effect the sample matrix has on the analysis of the samples. In an MS/MSD, the sample matrix is (1) identical to those submitted as samples, (2) spiked with known concentrations of target analytes, and (3) analyzed in exactly the same way as the other samples. One pair of MS/MSD samples was submitted to the laboratories for each group of samples (sediment, glass, quench water) and for each analysis requested (PCBs, dioxins and furans, VOCs, and SVOCs). The recoveries of all the MS/MSDs were in control, with the following exceptions. In the MS/MSD samples analyzed, three compounds were detected outside of established laboratory control limits. As a result, these detected compounds, which were not detected in the field samples, were qualified as estimated (UJ).

In one MS, 28 of 70 VOCs were detected below QC limits. For these compounds, any NDs in corresponding samples were qualified as estimated (UJ) and any detections were qualified as estimated (J).

4.4.4 Equipment Blanks, Field Blanks, and Method Blanks

Six equipment blanks and 11 field blanks, were collected during the GFT demonstration. PCBs were detected at low levels – less than 1 nanogram per liter in two of the field blank samples and less than 40 pg/g in two sand field blank samples. However, the congeners were not detected in samples associated with the field blank samples, and qualification of sample results was not warranted.

One sand field blank was collected and submitted to a laboratory for SVOC analysis. No SVOCs were detected at concentrations above method detection limits, and no qualification of samples associated with the sand blank was warranted.

None of the equipment and field blank samples was analyzed for dioxins and furans or metals. Ten method blanks were analyzed by the laboratory as well as two trip blanks for VOC analysis.

4.4.5 Audits

As a vital part of the QA program, one field audit and one laboratory audit were conducted by EPA to ensure that measurements associated with sampling and analysis were in conformance with the final QAPP (EPA 2001). The audit of field activities was conducted on June 21, 2001. Two findings and four

minor observations were documented. The first finding recommended collection of field blanks in the sample preparation area to document any potential impacts that fugitive dust might have on sediment and glass aggregate product samples. The second finding recommended the collection of sand blanks between crushed glass aggregate samples. Both of the recommendations were agreed upon and implemented. All of the minor observations were also agreed to and implemented.

The Paradigm Analytical Laboratory audit was conducted on March 21, 2001. Two observations were noted by the auditors. Paradigm addressed the observations, and data quality was not affected. The TER documents the results of these audits.

4.4.6 QAPP Sampling Deviations

For various reasons the number of samples specified in the QAPP were not collected. Table 4-17 list the planned sampling protocol, the actual samples collected, and the rationale for any changes in the QAPP.

4.5 OVERALL EVALUATION

Evaluation of the analytical data indicates that the GFT was able to significantly reduce PCB contamination in all samples collected. The GFT successfully destroyed 99.9995 percent of the total PCBs in the river sediment. The glass aggregate produced by Minergy's GFT met Wisconsin Administrative Code Chapter NR 538 Category 2 criteria and qualified for beneficial reuse under the regulation. This qualification allows a wide range of uses, including as an additive to concrete, a material in floor tiles, and as construction fill. It also requires environmental monitoring and regulatory notification under the accepted uses.

The GFT reduced the concentration of dioxins and furans in the dried sediment. Total dioxin and furan concentrations in the glass aggregate ranged from 1.77 to 3.77 pg/g, a reduction of greater than 99 percent.

The GFT appeared to be capable of decreasing mercury concentrations in the river sediment. Mercury was observed in sediment at a concentration slightly less than 1 part per million, and it was not detected in the glass aggregate analysis. If not removed by the furnace thermally, the mercury likely was inactivated within the glass matrix. Furnace flue gas samples did not detect mercury above method detection limits. Nor did mercury leach from the glass aggregate, as evidenced by the results of the American Society of Testing and Materials (ASTM) and Synthetic Precipitate Leaching Procedure

(SPLP) water leach tests.

Analysis of the sediment, glass aggregate product, and other output streams indicate that SVOCs and VOCs were not contaminants of any measure, and treatment of the sediment by the GFT did not create byproducts in the process waste streams. Similarly, dioxins and furans were observed at only minor concentrations in the glass aggregate product samples. The destruction of PCBs in the sediment did not cause hazardous constituents in the furnace flue gas to be released during operation.

Based on information from Minergy and observations made during the SITE evaluation, the estimated treatment cost is \$38.74 per ton of dredged-and-dewatered sediment containing 50 percent moisture. Unit costs may depend on the location of the treatment facility, sediment moisture, and potential product end use. Sale of the glass aggregate product would decrease the costs of treatment, but SITE's determination of process cost per ton of material did not take into account the sale of the glass aggregate.

TABLE 4-17

DISCREPANCIES TO QAPP SAMPLE PROTOCOL FOR MINERGY MELTING DEMONSTRATION

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSES SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
Dredged-and-dewatered sediment collected from roll-off boxes	Composite	-	-	-	5	PCB	6	Needed to collect samples of the wet sediment for calculation of the treatment efficiency
Dried, mixed sediment without flux addition To determine the variability of the material Collected from Supersacks	Composite	28	PCB	6	42	PCB	6	It was determined that three samples from each of 14 sacks should be split three ways to represent all sacks associated with each roll-off box above.
Dried, mixed sediment with flux addition To determine the chemical characteristics of the dried sediments prior to the melter Collected over 6-hour periods	Composite	24	PCB	6	24	PCB	6	Samples were collected at 15-minute intervals over 6-hour periods. Two additional dioxin/furan analyses were performed to better characterize the sediment entering the melter
	Composite	24	Dioxin/Furan	4	24	Dioxin/Furan	6	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	6	
	Composite	24	Mercury	6	24	Mercury	6	
	Composite	24	VOC	4	24	VOC	4	
Glass material from the melter To determine the chemical characteristics of the glass Collected over 6-hour periods	Composite	24	PCB	6	24	PCB	6	Samples were collected to match those collected of the sediment entering the melter. One VOC analysis was added to confirm the absence of VOCs in the glass
	Composite	24	Dioxin/Furan	4	24	Dioxin/Furan	4	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	6	
	Composite	24	Mercury	6	24	Mercury	6	
	Composite	-	VOC	-	24	VOC	1	

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSES SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
Glass material from the melter To determine the chemical characteristics of the leachate extracted off the glass surface Collected over 6-hour periods	Composite	24	PCB	6	24	PCB	12	PCB, metals, and mercury samples were analyzed with both ASTM and SPLP extractions, doubling the number of samples analyzed. Six, rather than 4, samples were analyzed for the full RCRA suite of metals because there was no difference in cost to analyze the suite and mercury only. Two additional dioxin/furan samples were analyzed because dioxins/furans were detected in pre-melter sediment
	Composite	24	Dioxin/Furan	4	24	Dioxin/Furan	5	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	12	
	Composite	24	Mercury	6	24	Mercury	12	
Glass material from the melter Crushed to <200 mesh To determine the chemical characteristics of the leachate extracted off the glass surface Collected over 6-hour periods	Composite	24	PCB	12	24	PCB	6	All crushed glass samples were analyzed with SPLP extractions only. Dioxin/furan analysis of crushed glass was not performed because this parameter was non-critical, the analyses were expensive, and analysis by ASTM and SPLP extractions had already been performed on the glass aggregate samples. It was expected that dioxins and furans, if present, would be adsorbed to the surface of the glass particles and crushing the glass would not cause a difference in concentration. Six samples were analyzed for the full RCRA suite of metals because there was no difference in cost to analyze the suite and mercury only.
	Composite	24	Dioxin/Furan	6	24	Dioxin/Furan	-	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	6	
	Composite	24	Mercury	6	24	Mercury	6	

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSIS SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
Glass material from the melter To determine the chemical characteristics of the leachate extracted off the glass surface Collected over 6-hour periods	Composite	24	PCB	6	24	PCB	12	PCB, metals, and mercury samples were analyzed with both ASTM and SPLP extractions, doubling the number of samples analyzed. Six, rather than 4, samples were analyzed for the full RCRA suite of metals because there was no difference in cost to analyze the suite and mercury only. Two additional dioxin/furan samples were analyzed because dioxins/furans were detected in pre-melter sediment
	Composite	24	Dioxin/Furan	4	24	Dioxin/Furan	6	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	12	
	Composite	24	Mercury	6	24	Mercury	12	
Glass material from the melter Crushed to <200 mesh To determine the chemical characteristics of the leachate extracted off the glass surface Collected over 6-hour periods	Composite	24	PCB	12	24	PCB	6	All crushed glass samples were analyzed with SPLP extractions only. Dioxin/furan analysis of crushed glass was not performed because this parameter was non-critical, the analyses were expensive, and analysis by ASTM and SPLP extractions had already been performed on the glass aggregate samples. It was expected that dioxins and furans, if present, would be adsorbed to the surface of the glass particles and crushing the glass would not cause a difference in concentration. Six samples were analyzed for the full RCRA suite of metals because there was no difference in cost to analyze the suite and mercury only.
	Composite	24	Dioxin/Furan	6	24	Dioxin/Furan	-	
	Composite	24	SVOC	4	24	SVOC	4	
	Composite	24	Metals	4	24	Metals	6	
	Composite	24	Mercury	6	24	Mercury	6	

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSES SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
City Water To determine the quality of the water entering the quench tank Collected at the beginning and the end of the 6-day period	Grab	NA	PCB	2	NA	PCB	1	One sample of city water was collected during the melter demonstration to save costs.
	Grab	NA	SVOC	2	NA	SVOC	1	
	Grab	NA	Metals	2	NA	Metals	1	
Quench Water To determine the quality of the water exiting the quench tank Collected over 6-hour periods	Composite	12	PCB	6	12	PCB	6	Two additional samples were analyzed for metals to better characterize the quench water
	Composite	12	SVOC	4	12	SVOC	4	
	Composite	12	Metals	4	12	Metals	6	
Discharge from Cooling Tower To determine the quality of the water discharged Collected at the beginning and end of the 6-day period	Grab	NA	PCB	2	NA	PCB	3	Recirculating pump broke down after the first sample was collected, and the system was remodeled to use fresh water. Two samples (including both SVOC samples) were collected after the cooling tower was retrofitted
	Grab	NA	SVOC	2	NA	SVOC	2	
	Grab	NA	Metals	2	NA	Metals	3	
Gas Sample Train 1 To determine the chemical characteristics of the materials discharged to the pollution control equipment Collected over 4 hours	Grab	NA	PCB	6	NA	PCB	6	No discrepancies
	Grab	NA	Dioxin/Furan	6	NA	Dioxin/Furan	6	
Gas Sample Train 2 To determine the chemical characteristics of the materials discharged to the pollution control equipment Collected over 4 hours	Grab	NA	SVOC	4	NA	SVOC	2	Samples for SVOC and VOC were reduced to conserve time during the demonstration. Due to plugging of the sample probe, sample collection for all samples took longer than planned.
	Grab	NA	Metals	4	NA	Metals	4	
	Grab	NA	HCl/Cl ₂	4	NA	HCl/Cl ₂	4	
Collected over 1 hour	Grab	NA	VOC	12	NA	VOC	2	

DESCRIPTION AND PURPOSE	SAMPLE TYPE	ANALYSES SPECIFIED IN QAPP			ACTUAL ANALYSES			RATIONALE FOR DIFFERENCE
		NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	NUMBER OF SAMPLES PER COMPOSITE	PARAMETER	NUMBER OF SAMPLES	
Accumulated dust deposited in the flue gas-sampling probe	Composite	-	Dioxins/Furan	-	8	Dioxins/Furan	3	Dust material was collected each time the probe was extracted and cleaned out. The material was composited over the entire day. Dust accumulation was not foreseen before the demonstration began.
	Composite	-	Metals	-	8	Metals	3	
Gas Sample Train To determine the chemical characteristics of the materials discharged by the pollution control equipment Collected over 4 hours	Grab	NA	PCB	3	NA	PCB	3	No discrepancies
	Grab	NA	Dioxin/Furan	3	NA	Dioxin/Furan	3	
	Grab	NA	SVOC	3	NA	SVOC	3	
	Grab	NA	Metals	3	NA	Metals	3	
Sample of Flux Additive To validate chemical characteristics of any additives to the process Collected from single lot	Grab	NA	PCB	2	NA	PCB	1	One sample of flux material was adequate to characterize any additives to the process
	Grab	NA	Dioxin/Furan	2	NA	Dioxin/Furan	1	
	Grab	NA	SVOC	2	NA	SVOC	1	
	Grab	NA	Metals	2	NA	Metals	1	

Notes: For sampling locations, see QAPP Figure 4-2
 - Sample not specified to be collected or analyzed
 ASTM - American Society for Testing and Materials
 SPLP - Synthetic Precipitate Leaching Procedure

5.0 TECHNOLOGY STATUS

This section discusses Minergy's development and use of the GFT and other vitrification technologies. It also examines the potential for the technology to be used at other sites or on a larger scale.

5.1 PREVIOUS EXPERIENCE

One version of Minergy's thermal technology is presently being used for recycling wastewater solids from 12 paper mills. The first step in the process is to transport wastewater solids (sludge) from a wastewater treatment facility to the glass aggregate plant. The received sludge is then conveyed into a closed-loop drying system, where the sludge is dried to approximately 90 percent solids.

In the next step, the sludge is conveyed from dryers to the glass furnace. Once in the furnace, the organic component of the sludge helps to fuel the high temperatures required to melt the dried sludge into glass. The inorganic component of the sludge melts and flows out of the furnace as molten glass. According to Minergy, while the high temperatures destroy the organic compounds, the melting process encapsulates trace metals contained in the sludge, permanently stabilizing the metals in an amorphous glass matrix.

The molten glass is discharged to a water quench system to form the glass aggregate product. The glass aggregate can be stored and handled similarly to conventional quarried aggregates. Some crushing and screening can be done offsite, if necessary to meet the size requirements of a particular aggregate market. Markets for the glass aggregate product include: floor tiles, abrasives, roofing shingles, asphalt and chip seal aggregates, and decorative landscaping.

The heat generated in the melting process is recovered by a heat-recovery steam generator to produce energy used to dry the wastewater solids, as well as to co-generate steam and electricity.

Minergy's Fox Valley glass aggregate plant in Neenah, Wisconsin, recycles 350,000 tons of wastewater solids annually, producing process steam for an adjacent paper mill and glass aggregate for resale.

Minergy claims that the GFT, an adaptation of this technology, is capable of remediating any contaminated river sediment. They claim that it will successfully remove or destroy contaminants from small and large volumes of sediment. Depending on the mineralogy of the sediment, application of the GFT can result in a quality glass product suitable for resale as a construction material. Minergy claims that typical contaminant-removal efficiencies are greater than 99 percent.

5.2

SCALING CAPABILITIES

Minergy has assessed several scenarios for construction and operation of a GFT system, based on the treatment of different amounts of sediment. Table 5-1 details the different scenarios assessed by Minergy and the resulting unit costs associated with each.

Although the cost analyses performed in this ITER are based on a project that would treat 1-million-tons of sediment, Minergy claims that melters could be scaled to accommodate sediment projects of most sizes. Table 5-1 shows how a larger project size results in lower unit costs. Areas where scale-up economies could be realized include the potential lower energy costs per ton of sediment treated, reduced sampling and analysis once treatment efficiencies have been established, and automation of some processes.

The estimated cost per ton is based on the facility operating for 24 hours per day, 350 days per year, over a 15-year project period. This schedule translates to treatment of 1.26 to 9.45 million tons of contaminated sediment over the life of the project.

**TABLE 5-1
SUMMARY OF PROJECT SIZE FOR SCALING AND UNIT COSTING**

Project Size	Description/Type	Dredged-and-Dewatered Sediment Capacity (tons/day)	Glass Aggregate Production (tons/day)	Minergy's Unit Cost (\$/ton) *
Small	Integrated	240	100	\$42.96
Mid-sized	Integrated	600	250	\$31.24
Mid-sized	Stand Alone	600	250	\$32.92
Mid-sized	Stand Alone	1,200	500	\$29.43
Large	Stand Alone	1,800	750	\$27.01

Notes: Tons/day - Tons per day

Minergy - Minergy Corporation

Costs are based on operation of the facility 350 days per year over 15 years.

\$/ton - Dollars per ton

* Source for unit costs - Minergy

Integrated - Located in proximity to an existing industrial facility, which would allow for sharing of some utilities

6.0 REFERENCES

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APPENDIX A
Congener and Analyte Lists

Appendix A
Complete List of Analytes

PCB		
(1)-MoCB	(40,71)-TeCB	153,168-HxCB
(4)-DiCB	64-TeCB	141-HxCB
(7)-DiCB	(61),70,74,(76)-TeCB	137-HxCB
(6)-DiCB	66-TeCB	(129),138,(163)-HxCB
(5)-DiCB	56-TeCB	158-HxCB
8-DiCB	60-TeCB	128,166-HxCB
(19)-TriCB	81-TeCB	167-HxCB
18,(30)-TriCB	77-TeCB	156,157-HxCB
(17)-TriCB	(88),91-PeCB	169-HxCB
(27)-TriCB	84-PeCB	(176)-HpCB
(24)-TriCB	90,101,(113)-PeCB	178-HpCB
(16)-TriCB	99-PeCB	187-HpCB
(26,29)-TriCB	86,87,97,(108),119,(125)-PeCB	183,185-HpCB
(25)-TriCB	(83,116)-PeCB	174-HpCB
31-TriCB	110-PeCB	177-HpCB
(20),28-TriCB	82-PeCB	(172)-HpCB
(21),33-TriCB	(107,124)-PeCB	180,(193)-HpCB
22-TriCB	123-PeCB	170-HpCB
37-TriCB	118-PeCB	190-HpCB
(50,53)-TeCB	114-PeCB	189-HpCB
(45,51)-TeCB	105-PeCB	202-OcCB
(46)-TeCB	126-PeCB	203-OcCB
52-TeCB	136-HxCB	208-NoCB
49,(69)-TeCB	135,151-HxCB	206-NoCB
(48)-TeCB	(147),149-HxCB	209-DeCB
44,47,(65)-TeCB	132-HxCB	
(59,62,75)-TeCB	146-HxCB	
PCDD/PCDF		
2,3,7,8-TCDD	OCDD	2,3,4,6,7,8-HxCDF
1,2,3,7,8-PeCDD	2,3,7,8-TCDF	1,2,3,7,8,9-HxCDF
1,2,3,4,7,8-HxCDD	1,2,3,7,8-PeCDF	1,2,3,4,6,7,8-HpCDF
1,2,3,6,7,8-HxCDD	2,3,4,7,8-PeCDF	1,2,3,4,7,8,9-HpCDF
1,2,3,7,8,9-HxCDD	1,2,3,4,7,8-HeCDF	OCDF
1,2,3,4,6,7,8-HpCDD	1,2,3,6,7,8-HxCDF	
METALS		
Arsenic	Chromium	Selenium
Barium	Mercury	Silver

Cadmium	Lead	
SVOC		
Phenol	Hexachlorobutadiene	N-Nitrosodiphenylamine
Bis(2-chloroethyl)ether	4-Chloro-3-methylphenol	4-Bromophenyl-phenylether
2-Chlorophenol	2-Methylnaphthalene	Hexachlorobenzene
1,3-Dichlorobenzene	Hexachlorocyclopentadiene	Pentachlorophenol
1,4-Dichlorobenzene	2,4,6-Trichlorophenol	Phenanthrene
Benzyl alcohol	2,4,5-Trichlorophenol	Anthracene
1,2-Dichlorobenzene	2-Chloronaphthalene	Di-n-butylphthalate
2-Methylphenol	2-Nitroaniline	Fluoranthene
3/4-Methylphenol	Dimethylphthalate	Pyrene
Bis(2-chloroisopropyl)ether	Acenaphthylene	Butylbenzylphthalate
N-Nitrosodiphenylamine	2,6-Dinitrotoluene	3,3'-Dichlorobenzidine
Hexachloroethane	3-Nitroaniline	Benzo(a)anthracene
Nitrobenzene	Acenaphthene	Chrysene
Isophorone	2,4-Dinitrophenol	Bis(2-ethylhexyl)phthalate
2-Nitrophenol	4-Nitrophenol	Di-n-octylphthalate
2,4-Dimethylphenol	Dibenzofuran	Benzo(b)fluoranthene
Benzoic acid	2,4-Dinitrotoluene	Benzo(k)fluoranthene
Bis(2-Chloroethoxy)methane	Diethylphthalate	Benzo(a)pyrene
2,4-Dichlorophenol	4-Chlorophenyl-phenyl ether	Indeno(1,2,3-cd)pyrene
1,2,4-Trichlorobenzene	Fluorene	Dibenzo(a,h)anthracene
Naphthalene	4-Nitroaniline	Benzo(g,h,i)perylene
4-Chloroaniline	4,6-Dinitro-2-methylphenol	
VOC		
1,1,1,2-Tetrachloroethane	2-Hexanone	Isopropylbenzene
1,1,1-Trichloroethane	4-Chlorotoluene	Methylenechloride
1,1,2,2-Tetrachloroethane	4-Methyl-2-pentanone	m-Xylene
1,1,2-Trichloroethane	Acetone	Naphthalene
1,1-Dichloroethane	Benzene	n-Butylbenzene
1,1-Dichloroethene	Bromobenzene	n-Propylbenzene
1,1-Dichloropropene	Bromochloromethane	o-Xylene
1,2,3-Trichlorobenzene	Bromodichloromethane	p-Isopropyltoluene
1,2,3-Trichloropropane	Bromoform	p-Xylene
1,2,4-Trichlorobenzene	Bromomethane	sec-Butylbenzene
1,2,4-Trimethylbenzene	Carbon disulfide	Styrene
1,2-Dibromo-3-chloropropane	Carbon tetrachloride	tert-Butylbenzene
1,2-Dibromoethane	Chlorobenzene	Tetrachloroethene
1,2-Dichlorobenzene	Chlorodibromomethane	Toluene
1,2-Dichloroethane	Chloroethane	trans-1,2-Dichloroethene

1,2-Dichloropropane	Chloroform	trans-1,3-Dichloropropene
1,3,5-Trimethylbenzene	Chloromethane	Trichloroethene
1,3-Dichlorobenzene	cis-1,2-Dichloroethene	Trichlorofluoromethane
VOC		
1,3-Dichloropropane	cis 1,3 Dichloropropene	Vinyl acetate
1,4-Dichlorobenzene	Dibromomethane	Vinyl chloride
2,2-Dichloropropane	Dichlorodifluoromethane	
2-Butanone	Ethylbenzene	
2-Chloroethyl vinyl ether	Fluorotrichloromethane	
2 Chlorotoluene	Hexachlorobutadiene	

APPENDIX B
Vendor Claims

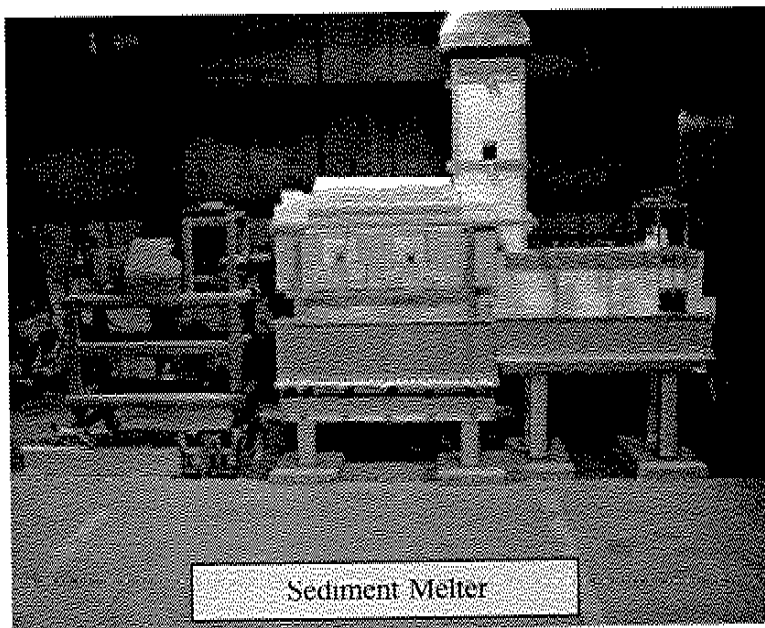
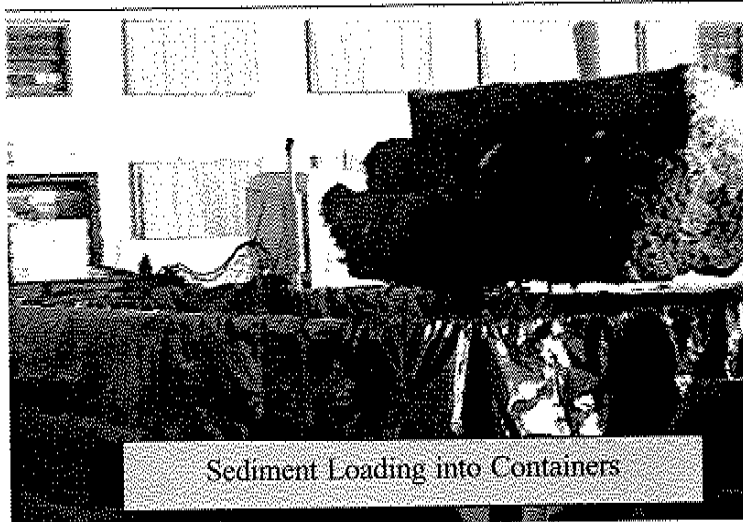
INTRODUCTION

This report is written to summarize the activities undertaken during the sediment melter demonstration project. This demonstration was Phase 3 of a multi-phase feasibility study. The first two phases of the feasibility study determined that the minerals contained in dredged sediments could form a stable glass, and that the variability of mineral concentrations along the lower Fox River appeared to be within acceptable ranges.

During a demonstration dredging project, the Wisconsin DNR containerized approximately 60 tons of de-watered, contaminated river sediment. The DNR contracted with Minergy for the design, construction, and operation of a pilot melter, to melt the sediment into a glass aggregate.

The melter evaluation was performed at Minergy's GlassPack Test Center in Winneconne, Wisconsin. A demonstration-scale melter was constructed, with operation of the melter from May to August, 2001. The pilot program was designed to confirm that the technology can destroy PCB contamination, stabilize trace metals, and convert the mineral content of river sediment into an inert, marketable construction material.

Under SITE program, the fate of PCBs and other compounds within the river sediment were monitored during the processing and melting of the river sediment.



SYSTEM DESIGN

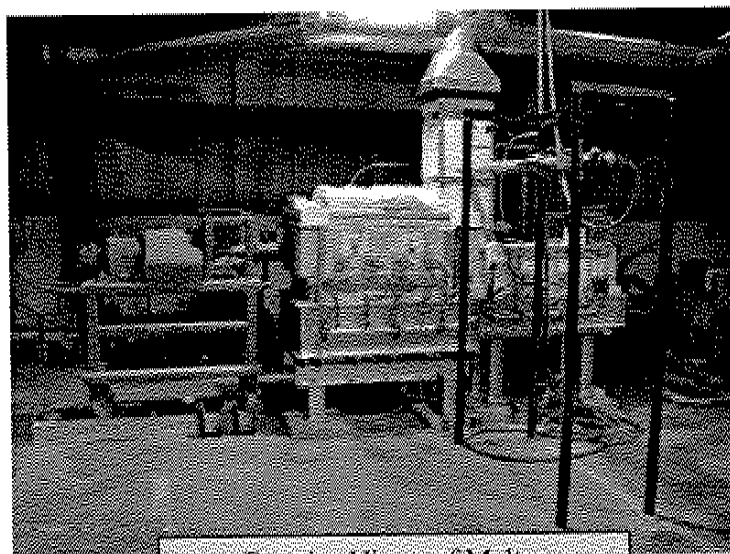
Phase III of the project included construction and operation of the sediment demonstration melter, and subjected to the monitoring by U.S. EPA SITE program. This phase was performed at Minergy's GlassPack Test Center in Winneconne, Wisconsin.

The pilot melter is designed to simulate a full-scale production melter for the generation of glass aggregate from sediments. In order to adequately produce a model, some assumptions have been made with regard to the full-scale melter in accordance with typical glass operating practices. The pilot melter is scaled down from the full-scale melter and has been designed to operate in a manner which would suggest design features for most major elements of the full scale melter.

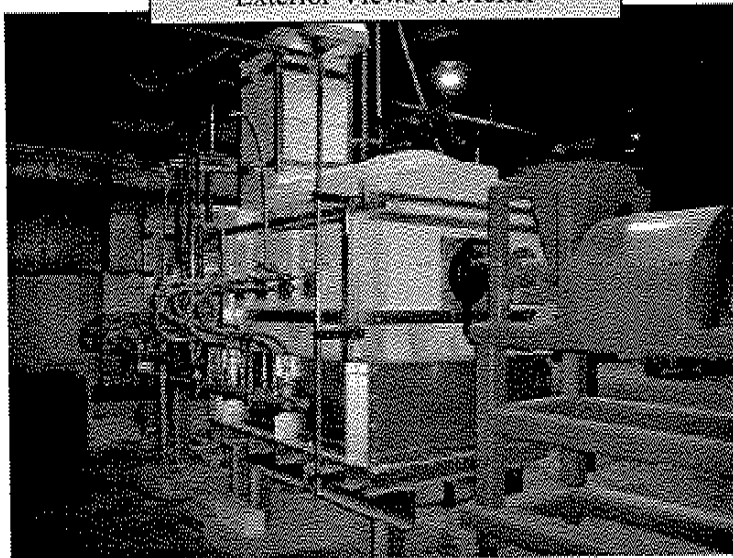
Pilot Melter Characteristics

Aspect Ratio	2:1
Area	10 sq ft.
Melting Rate	5.4 ft. ² /ton
Dwell Time	6 hrs.
Gas Usage	1.7 MM Btu/hr.
Oxygen Usage	35 ccfh
MM Btu/Ton	20.9 mmbtu/ton
Output	2 tons/day

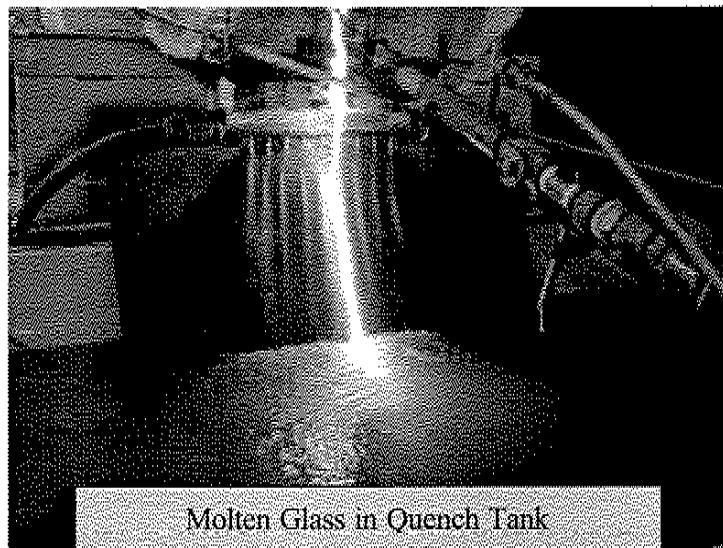
Several features were incorporated to the standard melter design in order to best suit this application. These modifications include:



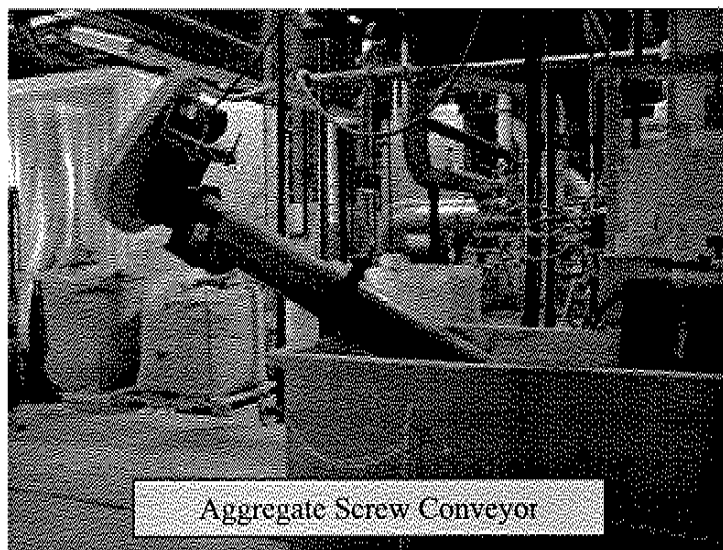
Exterior Views of Melter



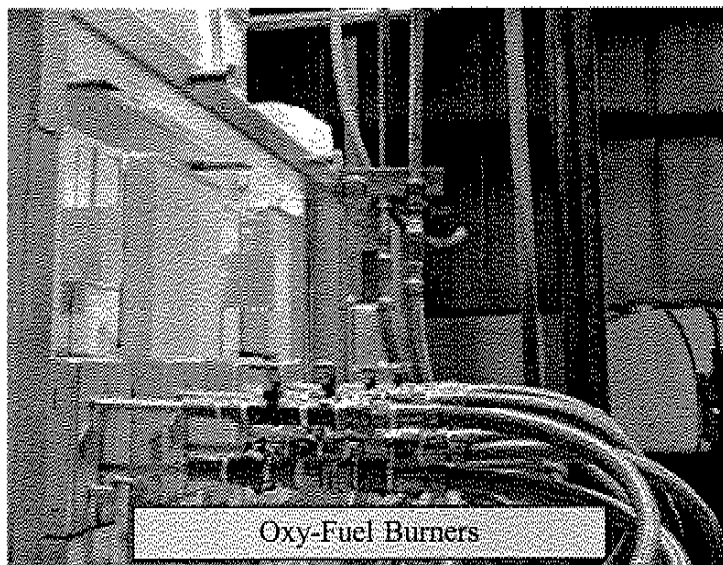
- The use of a water quench system to quickly harden the molten glass and increase the inert characteristics of the final product. Glass melters typically use annealing or other slow-cooling products to enhance glass clarity and other product qualities. These product features are not significant in the manufacture of glass aggregate because its final use is as a construction product where glass clarity is not necessary. Molten material is drained from the end of the melter into the water-filled quench tank. An inclined $\frac{1}{4}$ -inch steel plate, cooled by a constant water stream, directs falling liquid aggregate into the quench tank.
- An inclined screw conveyor removes hardened aggregate from the quench tank. The conveyor's hopper is submerged in the quench tank. The auger moves the aggregate out of the quench tank into barrels.
- The melter has eight Split-Stream oxy-fuel burners to approximate the burners that would be used in a full-scale melter. The melter is oxy-fuel fired to utilize the B.A.C.T. for NO_x emissions and reduced particulate.



Molten Glass in Quench Tank

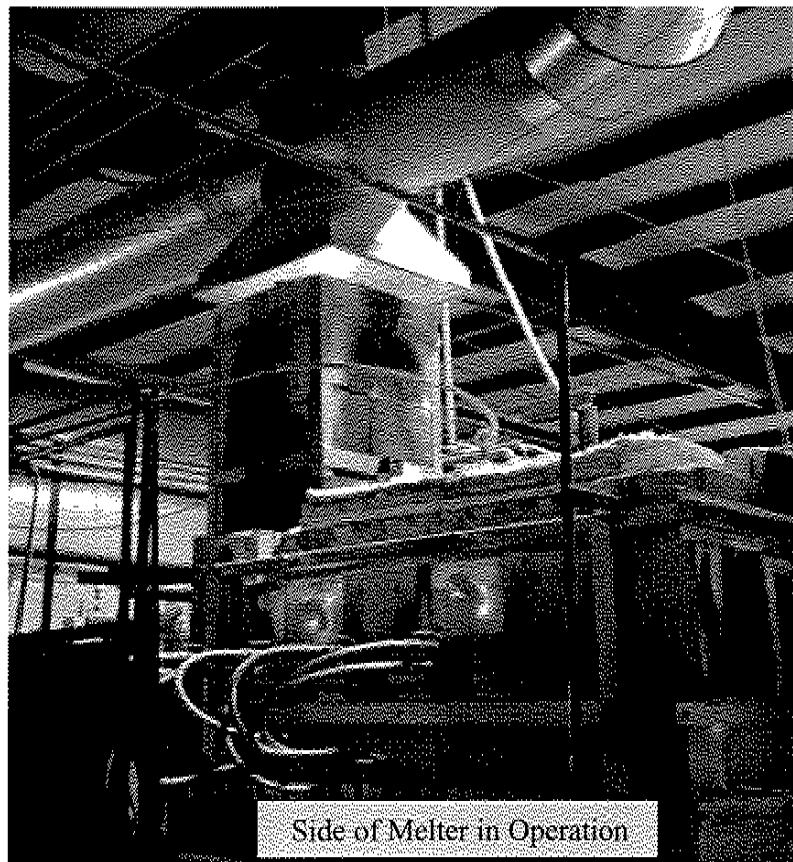
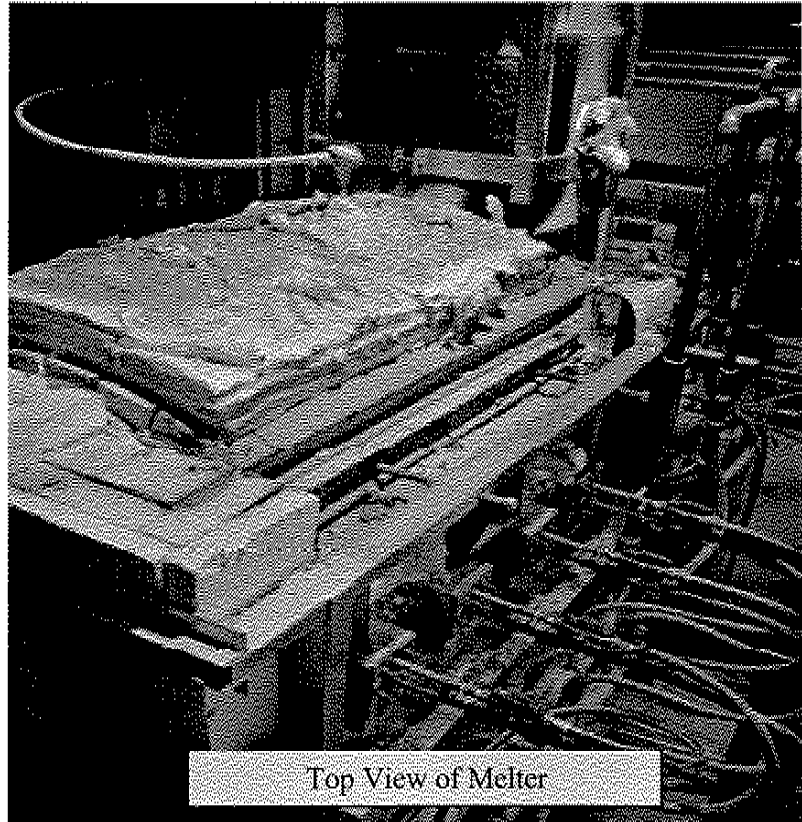


Aggregate Screw Conveyor

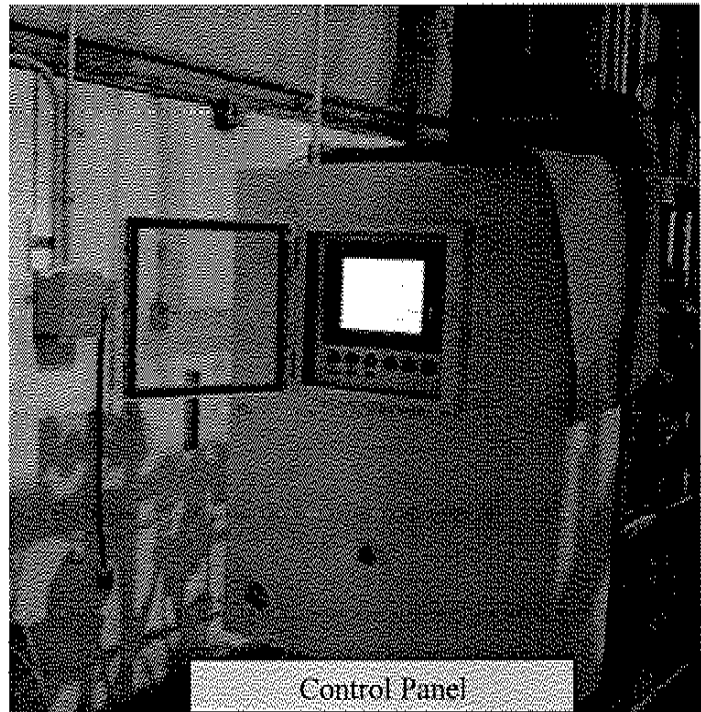


Oxy-Fuel Burners

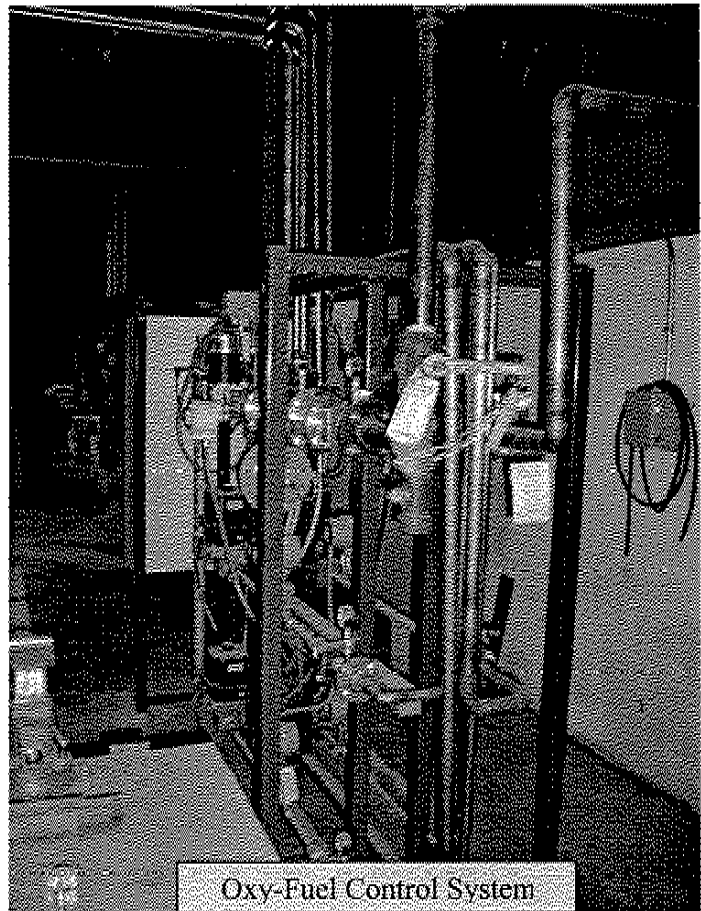
- The pilot melter is 10 square feet with a 2:1 aspect ratio. The materials selected are typical for soda-lime glass operations in an oxy-fuel environment. Six inches of extra sidewall has been added to the height to accommodate organics contained in the sediment feedstock. The glass quality is adequate with 6 hours of dwell time, so it runs a shallow glass level.
- The flue is located in the front of the melter, which is not the traditional location for oxy-fuel furnaces. This is done so that any fine particulate that becomes entrapped into the exhaust gases will have the maximum time in the furnace to allow these particulates to be melted, or minimized.
- The melter was designed and built under a contract with Frazier-Simplex of Washington, Pennsylvania.



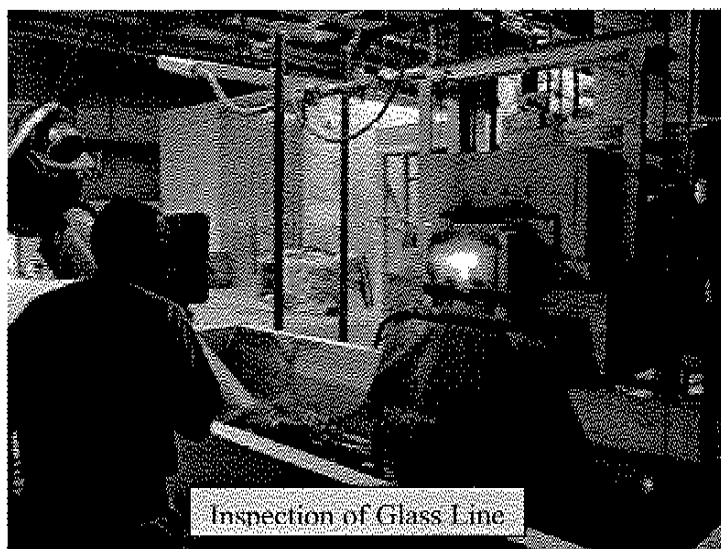
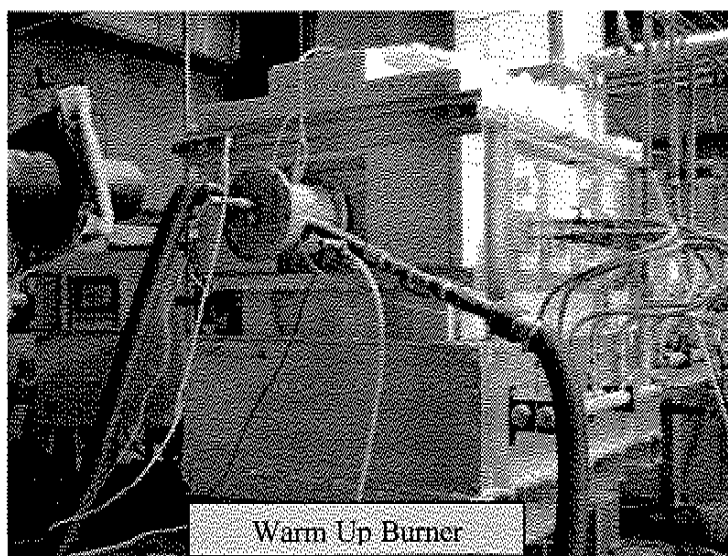
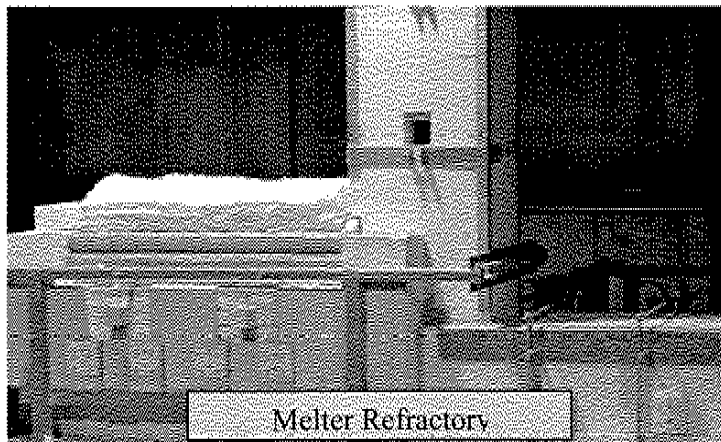
- The pilot melter is controlled by control loops to the melter and forehearth. The control loops use thermocouple signals to maintain a constant temperature by automatically adjusting the gas and oxygen for each zone. The control panel contains two single loop controllers, two digital gas flow meters, two digital oxygen flow meters, six digital temperature meters, status lights for the main fuel train, E-stop, alarm horn, and alarm silence push button.



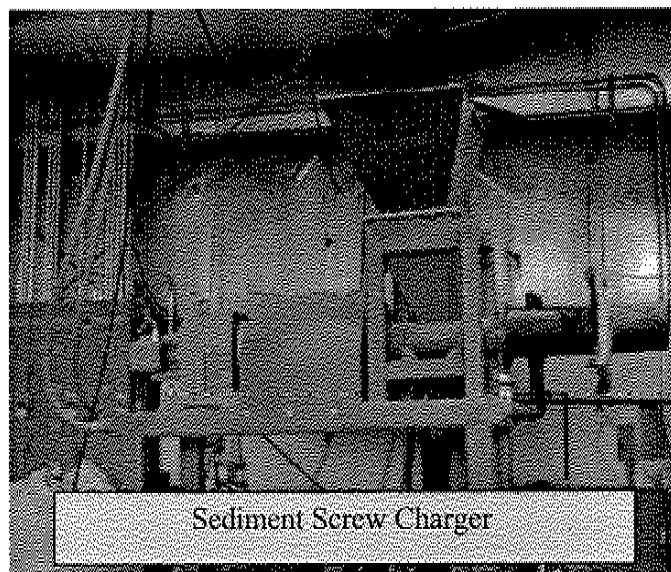
- Both the gas and oxygen skids have essentially the same safety system. A strainer is utilized prior to a pressure regulator. A high/low pressure switch is tied to the double block automatic shut-off valves. A differential pressure switch is used to determine flow through the system. This is a safeguard against injecting raw natural gas or oxygen into the furnace. If flow is lost on either natural gas or oxygen, the skid shuts down that zone. Each zone is then automatically controlled for gas and oxygen flows via a signal from the mass flow meter to a control loop back to an automatic valve.



- Refractory selection has been developed for this pilot melter based on the heat flow analyses for each construction type. These are used to insure that none of the materials is placed in temperatures beyond their capability and to determine the total heat loss of the entire system.
- The use of refractory selected by evaluating the abrasive qualities of the molten sediment. Glass products vary according to the chemical makeup of the feedstock. After the June run, an inspection of the inside of the forehearth verified that the refractory material at the glass line was seeing significant wear. The melter was relined with a higher grade refractory in place of the mullite originally installed in the melter for the August run.
- Startup of the melter is performed gradually over 36-48 hours. A separate, dedicated warmup burner is used to raise the temperature of the melter to approximately 1,400 degrees F. After this temperature, the main burners are used to reach final temperature target of 2,900 degrees F.
- The melter uses a "shallow" glass line. Glass melters typically have deeper pools of glass inside the melter, taking advantage of the low opacity of the glass being produced. Molten sediments are quite opaque, thus reducing energy transfer by radiation.



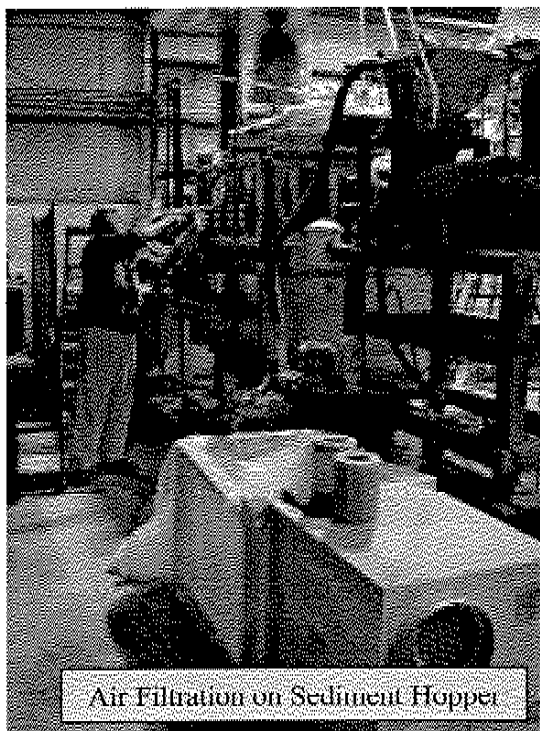
- Sediment is fed in on one end of the melter through a water-cooled screw charger. The charger is a standard screw batch charger that has been used all over the world for charging batch in glass furnaces. The screw charger was chosen due to the ability to tightly seal the charging hopper to the charger and the charger to the furnace. This minimizes dusting of the raw material feedstock. The charger is similar in size to that which would be used in a full-scale unit. It has been retrofitted with a small screw barrel and flights for the pilot melter. This charger can be reused for a full-scale melter by modifying the barrel and flights. A variable-speed drive allows control of the feed rate.
- Negative pressure and air filtration is placed on the feed hopper during charging operations to control dust.
- The melter design capacity is 2 tons per day or 170 pounds of river sediment per hour. The sediment bags weighed approximately 50 gross pounds, so the feed rate was between four and five bags per hour.



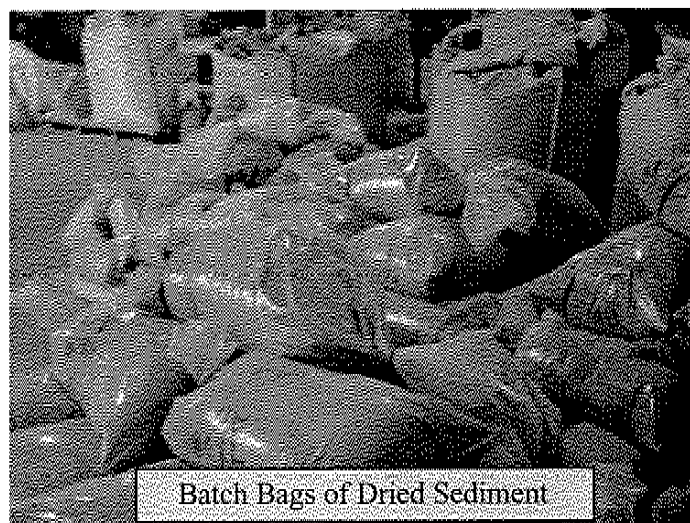
Sediment Screw Charger



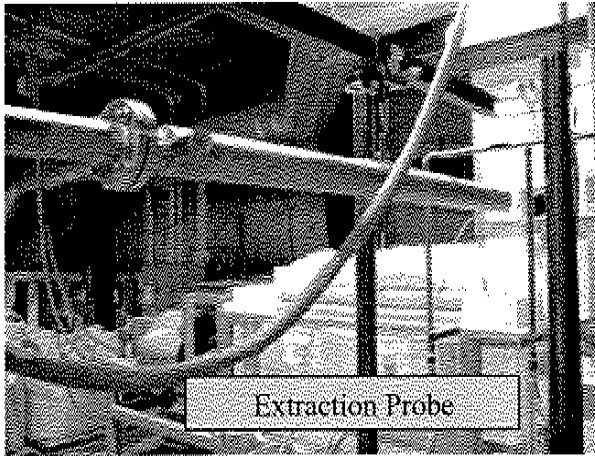
Sediment Feed



Air Filtration on Sediment Hopper



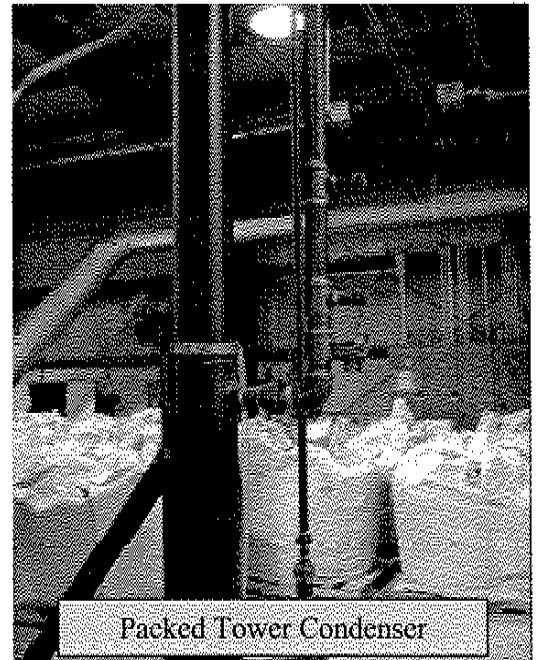
Batch Bags of Dried Sediment



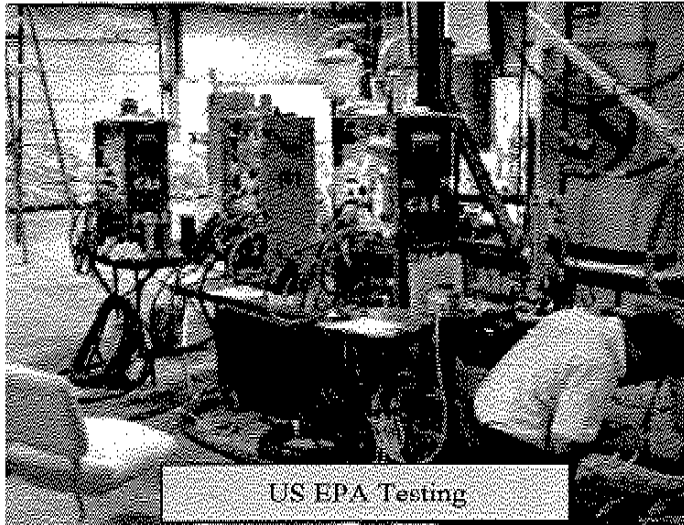
Extraction Probe

- An extraction probe is used to cool the hot gas from the melter exhaust at a controlled rate. The rate of cooling would be equivalent to the heat recovery systems installed on a full scale melter system.

The section of the probe which is inserted into the melter is contained in a water-cooled jacket, and is hung from a rail that allows it to be inserted into the stack for testing, then removed when testing is not taking place. A cleanout port is placed on the back end of the probe, and a brush and rod are used to manually clean out particulate buildup within the probe.



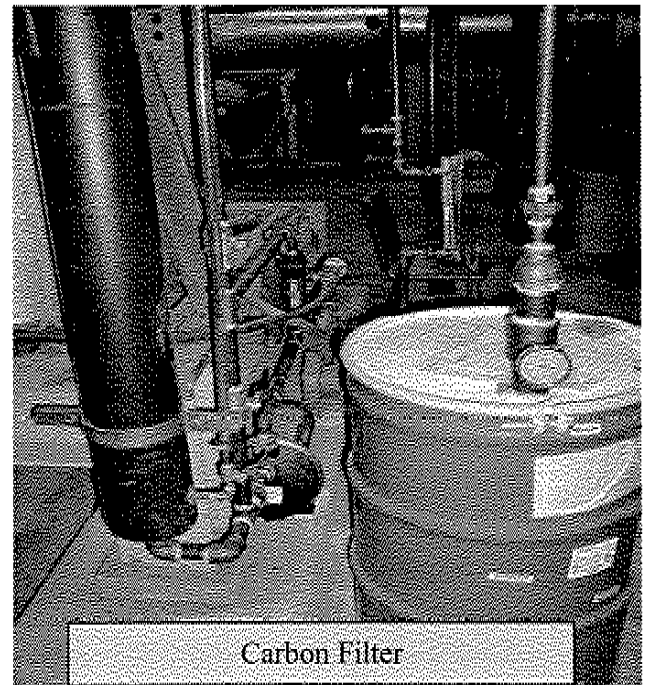
Packed Tower Condenser



US EPA Testing

- Sampling ports are located before the condenser and after the carbon filter, to allow connection of air testing equipment.

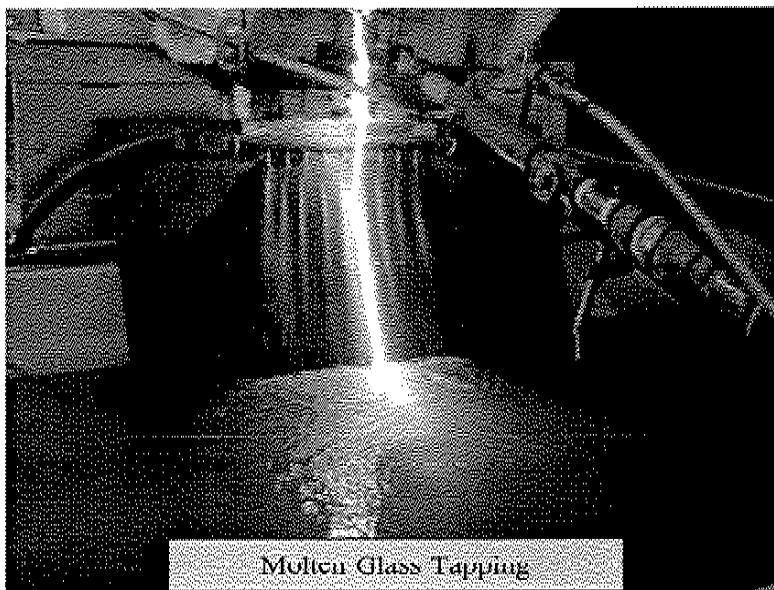
- Piping connects the extraction probe to a contact packed tower condenser. An induced draft fan pulls the exhaust gases through the tower condenser, and then through a carbon barrel, before discharging the air stream out of doors.



Carbon Filter

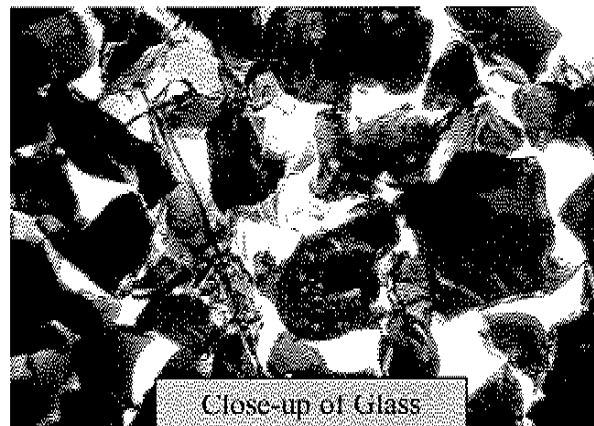
CONCLUSIONS

- The demonstration project determined that river sediment melts easily at high temperature into a hard, angular aggregate. The melter worked well with this type of feedstock, and the end product appeared consistent and marketable. When river sediment was being fed into the melter, temperatures within the melter were maintained between 2600 and 2900 degrees F.
- The demonstration clearly showed that sediment will successfully create a quality glass aggregate material using a glass furnace. The properties of the glass aggregate product were quite positive. The aggregate was very consistent, producing a hard, dark, granular material.



Conclusions Drawn From Results

- 1) PCB
 - a) Met the "six nines" criterion for stack basis Destruction Removal Efficiency
 - b) Treatment efficiency was 99.999488%
- 2) Dioxin
 - a) No 2,3,7,8 TCDD was detected in the stack either before or after the carbon filter
 - b) Greater than 99.9% removal of dioxins/furans both before and after the carbon filter
- 3) Mercury
 - a) No mercury was detected after the carbon filter
 - b) Removal efficiency was greater than 99.9%
- 4) Glass Aggregate
 - a) Leach test showed no-detect or no significant levels of any test parameter
 - b) PCB mass was less than that found in U.S. food supply and were not bioavailable



INTERPRETATION OF PROJECT RESULTS

1.0 Six Nines Destruction Removal Efficiency (DRE).

- 1.1 Background. Section 40 CFR 761.70 of federal environmental regulations sets forth requirements for processing PCB waste in a commercial facility. The requirement states that the mass air emissions shall be no greater than 0.001 gram PCB out per kilogram PCB in. Calculating the corresponding DRE by substituting 1000 grams for 1 kilogram, the "six nines" are derived:

$$\text{DRE} = (W_{\text{in}} - W_{\text{out}}) / W_{\text{in}} \times 100\%$$

$$\text{DRE} = (1000.0 - 0.001) / 1000.0 \times 100\%$$

$$\text{DRE} = 99.9999\%$$

The six nines are attributable to the six digits behind the decimal point in the decimal equivalent of a percentage (ie, 0.999999 = 99.9999%).

- 1.2 Calculation of the GFT's Six Nines DRE. The GFT demonstration met the Six Nines DRE. According to the EPA SITE report, the PCB concentrations were:

Sediment Entering Melter	27.8	parts per million
Flue Gas Exiting Melter	0.00000351	parts per million

Using the DRE formula,

$$\text{DRE} = (W_{\text{in}} - W_{\text{out}}) / W_{\text{in}} \times 100\%$$

$$\text{DRE} = (27.8 - 0.00000351) / 27.8 \times 100\%$$

$$\text{DRE} = 99.999987\%$$

As can be seen, the GFT achieved *greater* than the six nines reduction.

- 1.3 Discussion on ITER Treatment Efficiency. The U.S. EPA SITE Innovative Technology Evaluation Report calculates a Treatment Efficiency (TE) of the demonstration project of 99.9995%. It should be noted that the TE is not the same as the DRE specified in 40 CFR 761.70. Instead, the TE was calculated by summing the PCB concentrations of the flue gas, the quench water, and the glass aggregate.

2.0 Full Scale Implementation Expected To Be Even Better.

- 2.1 Quench Water. In a commercial facility, the aggregate tank quench water will be treated prior to discharge to the wastewater treatment plant. It is highly probable that the source of residual concentrations was small particles of glass aggregate suspended in the quench water. The combination of pre-treatment and wastewater treatment will be very effective in removing the suspended Glass Aggregate from the quench water. Therefore we would expect quench water PCB concentrations to be even lower in a full-scale system
- 2.2 Dust in Exhaust Gas. As indicated in the EPA report, the sample probe used for exhaust gas measurement was subject to accumulations of sediment dust. In a full-scale facility, a particulate control device would be used. No control device was used in the demonstration due to cost constraints. Devices of this sort are commercially available and are highly efficient at removal of dust. The collected dust would be re-directed back into the melter for treatment. Therefore we would expect the exhaust gas PCB concentrations to be even lower in a full-scale installation.
- 2.3 Residence Time. The melter used in the demonstration project had a 2 second gaseous residence time. The design of a full scale melter would allow for a gaseous residence time of 16 seconds. This longer residence time would be expected to significantly increase the destruction efficiency over that which was seen in the demonstration. Therefore we would expect the exhaust gas PCB concentrations to be even lower in a full-scale installation.

3.0 Glass Aggregate Product Is Very Inert.

- 3.1 Non-Leaching. As indicated in the EPA report, the PCBs in the Glass Aggregate were non-leachable for all tests, including those done on Glass Aggregate that had been finely ground. This is because the PCBs have either been destroyed or have been permanently stabilized in the ceramic matrix of the glass.
- 3.2 Not Bioavailable. As indicated in the attached Risk Perspective Toxicologist Report (issued as part of this section of Vendor Claims), PCBs in the Glass Aggregate are non-bioavailable and do not represent a health risk. The Toxicologist Report also shows that the PCBs detected in the Glass Aggregate are below background concentrations and are less than most foodstuffs in the American diet.
- 3.3 Exemption from Wisconsin DNR. The Wisconsin Department of Natural Resources has reviewed the EPA SITE report and the resultant data on the inertness of the Glass Aggregate. They have concluded that "the beneficial use of processed river sediment, as proposed, and in accordance with the conditions of this approval, will not result in environmental pollution." The WDNR has provided an exemption from all Wisconsin solid waste regulations for the Glass Aggregate.

Minergy Glass Aggregate A Risk Perspective

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March, 2003

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A. INTRODUCTION

In 2002-3, U.S. EPA conducted an innovative technology evaluation of Minergy Corporation's Glass Furnace Technology (Feb. 2003). This technology is a proposed ex situ remediation technology that has been designed to treat river/lake sediments contaminated with inorganic and/or organic materials. The product from the process is a black glass aggregate, comprised of particles the size of coarse sand.

As part of this U.S. EPA study, analytical testing was conducted on both the process input material (sediment) and its output product (aggregate). These data from the study indicated that there was >99.99% PCB and PCDD/PCDF¹ destruction, and that all chemical residuals that were remaining in the aggregate were non-leachable. Among other analytes, residual PCBs and PCDD/PCDF were identified in the glass aggregate. To put the residual concentrations of these specific analytes in the glass aggregate in perspective, Minergy Corporation contracted with STS Consultants, Ltd. to conduct a risk analysis on the material. Also addressed in this study was the residual PCB concentration detected in the process quench water.

The approach taken in this data interpretation study was to compare the residual PCB and PCDD/PCDF concentrations in the glass aggregate and PCB concentrations in the quench water to:

- typical background levels of these substances in the environment,
- risk-based remediation goals used in state/federal Superfund/RCRA programs, and/or
- other state guideline/rule concentrations of these chemicals.

B. GLASS AGGREGATE

Analytical Data

Shown in Table 1 are the residual PCDD/PCDF and PCB concentrations in the glass aggregate, as obtained from Table 4-5 of U.S. EPA's draft Innovative Technology Evaluation Report (2003).

¹ PCDD/PCDF = polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans.

PCDD/PCDF

As is shown in this table, the range of residual PCDD/PCDF (in total TCDD equivalents) in the aggregate was 0.1123 - 0.1565 pg/g, assuming each congener is present at its detection limit. The average concentration from the four samples using this conservative approach is 0.1376 pg/g. If the non-detected analytes were considered to not be present in the material, then the PCDD/PCDF concentration would be zero in three samples and 0.1565 pg/g in one sample. Averaging these values leads to a mean value of 0.0391 pg/g.

PCBs

Also shown in Table 1 are the residual PCB results on the glass aggregate. As is evident, there was a wide range of total PCB concentration within the samples. The range reported in the study was <26-1240 pg/g. The average total PCB concentration of the six samples (again conservatively assuming that the non-detected value was present at this detection limit) was calculated to be 414 pg/g.

Risk Analysis

To put the residual aggregate PCB and PCDD/PCDF data into perspective and to provide a qualitative risk evaluation of the glass aggregate, STS performed a comparison of the analytical data in Table 1 to soil background concentrations of these compound groups, to risk-based soil cleanup goals, and to background concentrations of these compounds in various foodstuffs. Also, the PCB concentration was compared to biosolids concentrations acceptable for landspreading in Wisconsin.

The foodstuff PCDD/PCDF concentrations listed in Table 1 were taken from Schecter et al. (1997). These investigators measured PCDD/PCDF in pooled food samples that were collected in 1995 at supermarkets across the United States.

PCDD/PCDF

As can be seen in Table 2, the glass aggregate PCDD/PCDF concentration is considerably less than typical soil background levels of these compounds and considerably less than typical risk-based cleanup goals for soils, calculated to be protective of human health. In fact, the glass concentration of PCDD/PCDF is less than most foodstuffs in the U.S. diet. Also, it is important to note that since these residual compounds were found to not be leachable from the glass aggregate, they will not be bioavailable, i.e., in a form that could be absorbed into the body, even if an individual such as a young child were to incidentally ingest some of this material. They also would not be bioavailable to fish and other aquatic life if the material were to be reintroduced back into a surface water system, i.e., as a sediment capping material.

Based on the above comparisons and analysis, it can be concluded that the residual PCDD/PCDF in the glass aggregate are at very low levels and will not present a significant risk to human health or the environment.

PCBs

As can be seen in Table 2, the glass aggregate PCB concentration is considerably less than typical risk-based cleanup goals for soils, calculated to be protective of human health, and less than Wisconsin DNR's soil criterion to be protective of wildlife. The residual PCB concentrations are also much less than typical biosolids concentrations that WDNR has approved for landspreading. The glass aggregate residual PCB concentration is less than or in the range of many of our foodstuffs in the U.S. diet. Also, as with the PCDD/PCDF, the residual PCBs in this glass aggregate were not found to be leachable.

Based on the above comparisons and analysis, it can be concluded that the residual PCB in the glass aggregate are at low levels and will not present a significant risk to human health and the environment.

C. QUENCH WATER

Analytical Data

Shown in Table 3 are the concentration data for PCB in the process stream quench water. These data were obtained from Table 4-7 of U.S. EPA's draft Innovative Technology Evaluation Report (2003).

As is evident, only two PCB congeners were found. The total PCB content in the water varied from <0.500 ng/L to 1.09 ng/L. Assuming that the non-detected total PCB values were present at the reported detection limits, the average PCB concentration from these six quench water samples was 0.615 ng/l. If the non-detected values were assumed to not be present in these samples, then the average concentration is 0.365 ng/L.

Risk Analysis

To put these residual PCB data into perspective, a comparison was made to the State of Wisconsin's Groundwater Standards. These standards have been developed to be protective of human health, assuming an individual ingests groundwater daily (as drinking water) throughout their lives. The WDNR's enforcement standard for PCBs is 30 ng/L; their Preventive Action Limit is 3 ng/L. It is therefore apparent that the residual PCB concentration in the process quench water, 0.365-0.615 ng/L is well below these safe drinking water exposure levels.

Since this process quench water would never ever be utilized as a drinking water source and will be treated prior to discharging to a sanitary sewer system (Minergy, personal communication), it can be concluded that the residual PCB in this water will not present a significant risk.

**Table 1: Glass Aggregate
Analytical Data (pg/g)^A**

A. PCDD/PCDF

<u>Congener</u>	<u>M-G-01</u>		<u>TCDD Equivalent</u>
	<u>Result</u>	<u>TEQ^B</u>	
1,2,3,7,8-PeCDD	<0.151	0.5	0.0755
1,2,3,7,8-PeCDF	<0.0684	0.05	0.0034
2,3,4,7,8-PeCDF	<0.0668	0.5	<u>0.0334</u>
		TOTAL	0.1123

<u>Congener</u>	<u>M-G-02</u>		<u>TCDD Equivalent</u>
	<u>Result</u>	<u>TEQ^B</u>	
1,2,3,7,8-PeCDD	0.173(J)	0.5	0.0865
1,2,3,7,8-PeCDF	0.149(J)	0.05	0.0075
2,3,4,7,8-PeCDF	0.125(J)	0.5	<u>0.0625</u>
		TOTAL	0.1565

<u>Congener</u>	<u>M-G-03</u>		<u>TCDD Equivalent</u>
	<u>Result</u>	<u>TEQ^B</u>	
1,2,3,7,8-PeCDD	<0.165	0.5	0.0825
1,2,3,7,8-PeCDF	<0.0826	0.05	0.0041
2,3,4,7,8-PeCDF	<0.0806	0.5	<u>0.0403</u>
		TOTAL	0.1269

<u>Congener</u>	<u>M-G-04</u>		<u>TCDD Equivalent</u>
	<u>Result</u>	<u>TEQ^B</u>	
1,2,3,7,8-PeCDD	<0.189	0.5	0.0945
1,2,3,7,8-PeCDF	<0.111	0.05	0.0056
2,3,4,7,8-PeCDF	<0.109	0.5	<u>0.0545</u>
		TOTAL	0.1546

B. PCBs

<u>Sample</u>	<u>PCBs (total)</u>
M-G-01	790
M-G-02	<26
M-G-03	58
M-G-04	27
M-G-05	1240
M-G-06	345

^A Data taken from Table 4-5 (Draft ITER, Minergy Corporation, Feb. 2003)

^B Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. U.S. EPA, 1998.

Table 2: Comparative Data

A. PCDD/PCDF

	Concentration (pg/g)
Minergy's Glass Aggregate	0.04 - 0.14 ^A (0.11-0.16)
freshwater fish ^B	1.43
butter ^B	1.07
hot dog/bologna ^B	0.54
ocean fish ^B	0.47
cheese	0.40
beef ^B	0.38
eggs ^B	0.34
ice cream ^B	0.33
chicken ^B	0.32
pork ^B	0.32
milk ^B	0.12
vegetables, fruits, grains, legumes ^B	0.07
soil (background) ^C	5.00 (0-57)
soil (risk-based remediation goal for residential land use)	20.00-200.00

B. PCBs

Minergy's Glass Aggregate	414 ^A (<26-1240)
fresh fish ^D	7481
hot dog/bologna ^D	3527
butter ^D	3234
ocean fish ^D	1758
chicken ^D	1040
beef ^D	980
pork ^D	879
cheese	584
eggs ^D	212
vegetables, fruits, grains, legumes ^D	159
soil (risk-based remediation goal for residential land use)	120,000 - 1,200,000
soil (WDNR wildlife criteria)	1900
WI Proposed PCB landspreading rule (2002) biosolids	
• 89% municipalities	>50,000
• median concentration	150,000

^A Mean value

^B Taken from USDA (2000) - www.mindfully.org/Food/Dioxins-Food-Chain_USDA2000.htm

^C www.nutrifor.com/dioxin_factsheet.htm

^D Schechter, A. et al. (1997) Chemosphere 5-7, 1437-47.

Table 3: Quench Water Analytical Data (ng/L)^A

<u>PCB Congener</u>	<u>Sample</u>					
	<u>M-QW-01</u>	<u>M-QW-02</u>	<u>M-QW-03</u>	<u>M-QW-04</u>	<u>M-QW-05</u>	<u>M-QW-06</u>
8-diCB	<0.500	0.513	<0.500	<0.500	<0.500	<0.500
18,(30)-TriCB	0.563	0.575	<0.500	0.539	<0.500	<0.500

^A Data taken from Table 4-7 (Draft ITER, Minergy Corporation, Feb. 2003)

APPENDIX C

Hazen Research Inc. Holoflite® Dryer Demonstration Results

HAZEN RESEARCH INC. HOLOFLITE® DRYER DEMONSTRATION RESULTS

January 9, 2001. Dredged-and-dewatered sediment was delivered to the Hazen Research, Inc. (Hazen), facility in Golden, Colorado, in four 55-gallon drums. The tackiness of the sediment hindered its flow through the feed hopper of the bench-scale dryer. After drying a portion of the sediment from one drum in a drum dryer, Hazen workers mixed dried sediment with dredged-and-dewatered sediment, using a coning-and-quartering technique. This technique was used to obtain an optimal moisture content for introducing sediment into the dryer.

January 15, 2001. Experimentation with dredged-and-dewatered and dried sediment continued in an effort to determine the right blending of material for feeding into the dryer. Work centered on the sediment in the second drum (barrel), designated Barrel 2, which, after removal from the barrel, was coned and quartered several times. The sediment was wetter than that from Barrel 1 and required more dried sediment to obtain the right consistency. Mixing was accomplished with a pug mill.

January 16, 2001. The remainder of the sediment to be used in the Holoflite®-dryer test was mixed through the pug mill to get a suitable consistency. The workable sediment was re-mixed in the pug mill and placed in plastic bags for the bench-scale test.

Overall, three drums were prepared for the Holoflite® -dryer test. One-and-three-eighths barrels of the wet soil was oven dried and remixed with one-and-five-eighths barrels of wet soil in the pug mill.

January 22, 2001. Joe Dauchy, Ken Brown, and Ken Partymiller (Tetra Tech EM Inc.); and Rob Paulson (Wisconsin Department of Natural Resources [WDNR]) arrived at Hazen and met Dennis Johnson (Hazen) at 10:30 am. Mr. Johnson took everyone present on a tour of the Hazen facility. Marta Richards (U.S. Environmental Protection Agency [EPA]) arrived and noted the need for a meeting to discuss the mixing that had occurred during the previous week and the sampling proposed for the current week. It was decided that the sampling should be reduced to six runs (from eight) because of time constraints. Also, the numbers of dioxins and furans, semivolatile organic compounds (SVOCs), and metals analyses were reduced, because they were not associated with the primary objectives. The sample-labeling protocol also was discussed. The sampling-and-analysis planning document discusses the sampling and analyses for the dryer test. The samples were labeled as follows:

HZ - Hazen Dryer Test

B1 - Batch #1

SI - Sediment in

SO - Sediment out

Example: HZB3SO = Hazen dryer test of Batch #3, Sediment Out

Sampling supplies were unpacked and shipments from laboratories were checked to ensure that everything had arrived.

January 23, 2001. Terry Carroll (Minergy) arrived today. Mr. Johnson (Hazen) stated that the balance used to measure the sediment going in and coming out of the dryer is calibrated every month by an outside contractor. The dryer was warmed up and ready to start at 9:00 am. Mr. Dauchy monitored the operational parameters (temperatures) of the dryer.

Run #1 began at 9:00 am and ended at 11:00 am. One "run", or batch, consisted of sediment running through the dryer over a 2-hour period. Weights of the grab-and-composite soil samples collected from each run were entered in field logbooks. About 200 grams (g) of pre- and post-dryer samples were collected every half-hour during each run. Composite samples (pre- and post-dryer) from each run provided enough material for polychlorinated biphenyl (PCB), dioxin and furan, SVOC, and metals analyses. Samples were containerized and put in the appropriate coolers for shipment to Kemron Environmental Services (Kemron) in Marietta, Ohio, and Paradigm Analytical Laboratories (Paradigm) in Wilmington, North Carolina. All of the condensate was collected and weighed for each run. At the end of the run, the condensate was poured into sample containers for PCB, dioxin and furan, SVOC, and metals analyses. Runs #1 through #3 were conducted and sampled.

January 24, 2001. Run #4 began at 8:00 am. Pre- and post-dryer sediment and condensate were sampled for PCB, dioxin and furan, SVOC, and metals analysis. Videographers arrived to videotape the process. Mr. Paulson took several samples of the dried sediment and shipped them to the Wisconsin State Laboratory for analysis of PCBs. The Holoflute® dryer was drying sediment to approximately 5 percent moisture. Runs #4 through #6 were completed and sampled today. Run #6 was lengthened by 45 minutes to collect additional water for a duplicate and matrix spike/matrix spike duplicate (MS/MSD) for SVOC analysis.

January 25, 2001]. Mr. Dauchy and Mrs. Richards discussed and approved collection of one set of samples for a single run (Run #7), in case the operational parameters of the dryer were different from the previous 2 days. Run #7 started at 10:30 am and ended at 12:30 p.m. Operational temperatures were recorded throughout the day. Samples were containerized and shipped to Kemron and Paradigm. The following tables summarize the analytical results of sampling conducted during the Holoflite®-dryer demonstration. Table C-1 summarizes the Sediment-In sample analytical results. Table C-2 summarizes the analytical results of the Sediment-Out composite samples. Table C-3 contains the analytical results of the condensate samples, and Table C-4 summarizes the air-sample analytical results. The data indicate a significant increase in PCB and dioxin and furan concentrations from pre-dryer to the post-dryer samples. Increases in metals and SVOC concentrations were not observed from pre-to post-dryer samples. Analytical results exhibited detections of some PCB congeners in the air and condensate samples collected during the dryer demonstration. This was probably attributable to carryover of sediment dust from the dryer chamber to the air stream exiting the dryer.

About 25 PCB congeners were specified to the laboratory for analysis. This list was based on toxic congeners listed by the World Health Organization. The 25 congeners analyzed did not correlate well with the congeners discharged to the Fox River. Total PCB values for each sample were not requested and therefore were not provided by the laboratory. A comparison of the PCB results (for both individual congeners and total PCBs) for the dredged-and-dewatered sediment and previous results obtained by the WDNR could not be made. The designated high-resolution analytical method (EPA Method 1668) (EPA 1997) was inappropriate for the elevated levels of PCBs in the sediment (parts-per million range). Many of the analytical results exceeded the calibration range and thus were estimated.

Based on the results of the Holoflite®-dryer demonstration, it was decided that the dryer test was flawed by the carryover of dust into the air and condensate streams, as well as the congener incompatibility in the dryer test and the melter test. In addition, the increase in PCB and dioxin and furan concentrations in dried sediment could not be explained.

TABLE C-1
HAZEN HOLOFLITE® DRYER COMPOSITE SEDIMENT-IN SAMPLE RESULTS

Analyte (parts per million)	Sample Identification					
	HZB1SI	HZB2SI	HZB3SI	HZB4SI	HZB5SI	HZB6SI
Total PCBs ^a	1.7	2.6	3.1	8.2	8.0	9.5
Total PCDDs/PCDFs ^b	0.0062	- ^c	-	0.024	0.016	-
Arsenic	8.7	9.7	9.3	9.3	9.2	9.6
Barium	84	84	85	78	83	83
Cadmium	0.95	0.94	0.95	0.95	1.0	1.0
Chromium	37	37	40	36	39	37
Mercury	0.94	0.91	0.89	0.92	0.88	0.87
Lead	72	71	73	75	77	74
Selenium	4.5	4.5	5.3	4.1	4.7	4.7
Silver	<3.1 ^d	<3.1	<3.2	<3.2	<3.1	<3.1
Total SVOCs ^e	<0.26	0.3	-	<0.26	<0.26	0.3

Note: a PCBs = Polychlorinated biphenyls. Total PCBs are based on the sum of 23 congeners
b PCDDs/PCDFs = Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
c - = not sampled
d < = less than
e SVOCs = Semi-volatile organic compounds

TABLE C-2
HAZEN HOLOFLITE® DRYER COMPOSITE SEDIMENT-OUT SAMPLE RESULTS

Analyte (parts per million)	Sample Identification					
	HZB1SO	HZB2SO	HZB3SO	HZB4SO	HZB5SO	HZB6SO
Total PCBs ^a	14	14	12	14	14	14
Total PCDDs/PCDFs ^b	0.047	- ^c	-	0.055	0.054	-
Arsenic	8	7.5	7.9	8.3	7.9	8.6
Barium	81	81	83	77	73	80
Cadmium	0.9	0.91	0.89	0.95	0.94	1.0
Chromium	37	37	37	34	34	37
Mercury	0.89	0.94	0.8	0.82	0.87	0.84
Lead	70	68	69	72	67	75
Selenium	5.4	5.5	4.8	5.1	6	6.3
Silver	<2.1 ^d	<2.1	<2.2	<2.1	<2.1	<2.1
Total SVOCs ^e	2.3	1.8	-	2.7	2.5	1.4

Note: a PCBs = Polychlorinated biphenyls. Total PCBs are based on the sum of 23 congeners
b PCDDs/PCDFs = Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
c - = not sampled
d < = less than
e SVOCs = Semi-volatile organic compounds

TABLE C-3
HAZEN HOLOFLITE[®] DRYER CONDENSATE-OUT COMPOSITE SAMPLE RESULTS

Analyte (parts per million)	Sample ID					
	HZB1CO	HZB2CO	HZB3CO	HZB4CO	HZB5CO	HZB6CO
Total PCBs ^a	0.53	0.47	0.21	0.30	0.50	0.57
Total PCDD/PCDFs ^b	4.0 x 10 ⁻⁶	- ^c	-	7.5 x 10 ⁻⁶	1.7 x 10 ⁻⁵	1.4 x 10 ⁻⁵
Arsenic	0.04	0.018	-	0.026	0.021	-
Barium	0.016	0.023	-	0.015	0.014	-
Cadmium	<0.01 ^d	<0.01	-	<0.01	<0.01	-
Chromium	<0.02	<0.02	-	<0.02	<0.02	-
Mercury	0.0003	0.00023	-	<0.0002	0.00023	-
Lead	<0.005	0.009	-	0.0061	0.0077	-
Selenium	<0.01	<0.01	-	<0.01	<0.01	-
Silver	<0.01	<0.01	-	<0.01	<0.01	-
Total SVOCs ^e	0.22	0.23		0.15	0.21	0.29

Note: a PCBs = Polychlorinated biphenyls. Total PCBs are based on the sum of 23 congeners
b PCDDs/PCDFs = Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
c - = not sampled
d < = less than
e SVOCs = Semi-volatile organic compounds

TABLE C-4
HAZEN HOLOFLITE® DRYER AIR SAMPLE RESULTS

Sample ID	Parameter									
	Total PCDDs/PCDFs ^d (ng) ^e	Arsenic (ppm)	Barium (ppm)	Cadmium (ppm)	Chromium (ppm)	Mercury (ppm)	Lead (ppm)	Selenium (ppm)	Silver (ppm)	Total SVOCs ^f (µg) ^g
300267	1.43									
300270	1.25									
300272	1.77									
300274	0.74									
300277	2.54									
300280	2.96									
300283										82
300285										64
300287										220
300289										198
300291										207
300293										225
300319		<0.004 ^h	<0.01	<0.01	<0.02	<0.0002	<0.005	<0.01	<0.01	
300320		<0.004	<0.01	<0.01	<0.02	<0.0002	<0.005	<0.01	<0.01	
300321						0.023				
300322						<0.0002				

Sample ID	Parameter									
	Total PCDDs/PCDFs ^d (ng) ^e	Arsenic (ppm)	Barium (ppm)	Cadmium (ppm)	Chromium (ppm)	Mercury (ppm)	Lead (ppm)	Selenium (ppm)	Silver (ppm)	Total SVOCs ^f (μg) ^g
300323						<0.0002				
300327						<0.0002				
300328		<0.004	<0.01	<0.01	<0.02	<0.0003	<0.005	<0.01	<0.01	
300329		<0.004	<0.01	<0.01	<0.02	<0.0003	<0.005	<0.01	<0.01	
300330						0.048				
300331						<0.0002				
300332		<0.004	<0.01	<0.01	<0.02	<0.0002	<0.005	<0.01	<0.01	
300333						<0.0002				
300334		<0.004	<0.01	<0.01	<0.02	<0.0004	<0.005	<0.01	<0.01	
300335		<0.004	<0.01	<0.01	<0.02	<0.0002	<0.005	<0.01	<0.01	
300336		<0.004	<0.01	<0.01	<0.02	<0.0003	<0.005	<0.01	<0.01	
300337		<0.004	<0.01	<0.01	<0.02	<0.0003	<0.005	<0.01	<0.01	
300338						0.038				
300339						<0.0002				
300340		<0.004	<0.01	<0.01	<0.02	<0.0003	<0.005	<0.01	<0.01	

Sample ID	Parameter									
	Total PCDDs/PCDFs ^d (ng) ^e	Arsenic (ppm)	Barium (ppm)	Cadmium (ppm)	Chromium (ppm)	Mercury (ppm)	Lead (ppm)	Selenium (ppm)	Silver (ppm)	Total SVOCs ^f (µg) ^g
300341		<0.004	<0.01	<0.01	<0.02	<0.0002	<0.005	<0.01	<0.01	
300342						0.12				
300343						<0.0002				

Notes: a ID = Identification
b PCBs = Polychlorinated biphenyls. Total PCBs are based on the sum of 23 congeners.
c ppm = parts per million
d PCDDs /PCDFs = Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans
e ng = Nanogram
f SVOCs = Semivolatile organic compounds
g µg = Microgram
h < = Less than

APPENDIX D

Wisconsin Administrative Code Chapter NR 538

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Chapter NR 538

BENEFICIAL USE OF INDUSTRIAL BYPRODUCTS

NR 538.01	Purpose.	NR 538.10	Beneficial uses.
NR 538.02	Applicability.	NR 538.12	Beneficial uses for specific categories of industrial byproducts.
NR 538.03	Definitions.	NR 538.14	Reporting.
NR 538.04	Performance standards.	NR 538.16	Storage and transportation requirements.
NR 538.05	Solid waste rules exemption.	NR 538.18	Public participation.
NR 538.06	Industrial byproduct characterization.	NR 538.20	Environmental monitoring.
NR 538.08	Industrial byproduct categories.	NR 538.22	Property owner notification.

NR 538.01 Purpose. The purpose of this chapter is to allow and encourage to the maximum extent possible, consistent with the protection of public health and the environment and good engineering practices, the beneficial use of industrial byproducts in a nuisance-free manner. The department encourages the beneficial use of industrial byproducts in order to preserve resources, conserve energy, and reduce or eliminate the need to dispose of industrial byproducts in landfills. This chapter is adopted under ss. 289.05, 289.06, 289.43 (4), (7) and (8), Stats. and 227.11, Stats.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.02 Applicability. (1) Except as otherwise provided, this chapter governs the beneficial use of industrial byproducts, except hazardous waste and metallic mining waste.

(2) This chapter does not apply to the design, construction or operation of industrial wastewater facilities, sewerage systems and waterworks treating liquid wastes approved under s. 281.41, Stats., or permitted under ch. 283, Stats., nor to facilities used solely for the disposal of liquid municipal or industrial wastes which have been approved under s. 281.41, Stats., or permitted under ch. 283, Stats., except facilities used for the disposal of solid waste.

Note: The landspreading of wastewater treatment sludges is regulated under chs. NR 206 and 214. The landspreading of solid wastes is regulated under ch. NR 518.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.03 Definitions. The following definitions as well as the definitions in ch. 289, Stats., and s. NR 500.03 are applicable to the terms used in this chapter unless the context requires otherwise.

(1) "Base course" means the layer or layers of specified or selected material of designated thickness placed on a subbase or subgrade to support a pavement or other structure.

(2) "Industrial byproduct" means papermill sludge, coal ash including slag, foundry excess system sand, foundry slag or other non-hazardous solid waste with similar characteristics as determined by the department.

(3) "Residential area" means properties that are zoned as residential, are in areas planned for residential zoning under a master plan approved or adopted by a local municipal authority or those portions of properties on which there is a residence for human habitation that are within 200 feet of the residence.

(4) "Subbase" means the layer or layers of specified or selected material placed on a subgrade to support a base course.

(5) "Subgrade" means the top soil surface upon which a subbase or base course are placed.

(6) "Subgrade fill" means the layer or layers of material placed above the natural ground surface to achieve a subgrade.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.04 Performance standards. No person may store, handle or beneficially use an industrial byproduct in a manner that may cause any of the following:

- (1) A significant adverse impact on wetlands.
- (2) A significant adverse impact on critical habitat areas.

(3) A detrimental effect on any surface water.

(4) A detrimental effect on groundwater quality or will cause or exacerbate an attainment or exceedance of any preventive action limit or enforcement standard at a point of standards application as defined in ch. NR 140.

(5) The migration and concentration of explosive gases in any structures, or in the soils or air at or beyond the project property boundary in excess of 25% of the lower explosive limit for the gases at any time.

(6) The emissions of any hazardous air contaminant exceeding the limitations for those substances contained in s. NR 445.03.

Note: The placement of materials in a floodplain where an obstruction to flood flows or an increase in regional flood event or an adverse affect upon a drainage course is regulated under ch. NR 116.

Note: The emissions of particulates and volatile organic compounds are regulated under s. NR 415.03 and chs. NR 419 to 424.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.05 Solid waste rules exemption. (1) **GENERAL.** Persons who generate, use, transport or store industrial byproducts that are characterized and beneficially used in compliance with this chapter are exempt from licensing under s. 289.31, Stats., and the regulatory requirements in chs. NR 500 to 536.

(2) **EXISTING EXEMPTIONS.** This chapter does not abrogate, rescind or terminate an approval or grant of exemption in effect on January 1, 1998 that was issued under s. 289.43 (7) or (8), Stats. Nothing in this subsection limits the authority of the department to modify, terminate or rescind any approval or grant of exemption as provided by law.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.06 Industrial byproduct characterization.

(1) **GENERAL.** Industrial byproducts that are beneficially used under this chapter shall be characterized as specified in this section to determine their appropriate categorization under s. NR 538.08. The results of this characterization shall be reported to the department as specified in s. NR 538.14. The testing program for materials not specifically listed in tables 1A to 3 shall be approved by the department prior to characterization. For those materials not listed in tables 1A to 3 the department may modify the list of parameters required to be analyzed for and may establish standards on a material specific basis for additional parameters.

(2) **INITIAL CHARACTERIZATION.** A representative sample of an industrial byproduct shall be properly characterized prior to beneficial use to determine its category under s. NR 538.08.

(3) **CHARACTERIZATION METHODS.** (a) The limits of detection used in the characterization shall be at or below the concentration listed in tables 1A to 3 for each parameter for the specific target category where possible. When a limit of detection at or below a target category standard is not achievable, or if no concentration is listed, the method that will achieve the lowest detection limit shall be used. All material sampling, total elemental analyses and analyses of elutriate from leach testing shall be performed using EPA SW-846 methods, unless otherwise approved by the depart-

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ment. The limit of detection and the limit of quantitation shall be reported with the sample results. If a substance is detected below the limit of quantitation, the detected value with the appropriate qualifier shall be reported.

(b) All industrial byproducts that are to be beneficially used under this chapter shall be determined not to be a hazardous waste as defined under s. NR 600.03 (98) using a method specified under ch. NR 605.

(c) All industrial byproducts which are characterized to determine eligibility for category 1 to 4 under s. NR 538.08 (1) to (4) shall be analyzed using the most recent revision of the ASTM D3987 water leach test.

(d) All industrial byproducts which are characterized to determine eligibility for category 1 or 2 under s. NR 538.08 (1) or (2) shall be analyzed using a total elemental analysis, unless another analysis method is approved by the department.

Note: Copies of EPA SW-846 are available for inspection at the offices of the department of natural resources, the secretary of state and the revisor of statutes. Copies may be obtained from the national technical information service, 5295 port royal road, Springfield, Virginia 22161. Phone (703) 487-4600.

Note: ASTM-D3987 is the American society for testing and materials "Test Method for Shake Extraction of Solid Wastes with Water." Copies of this test procedure can be obtained from the American society for testing and materials (ASTM), 1916 race street, Philadelphia, Pennsylvania, 19103-1187. (215) 299-5400. Copies of these test methods are also available for inspection at the offices of the department, the secretary of state and the revisor of statutes.

(4) **RECHARACTERIZATION.** (a) Industrial byproducts that are beneficially used under this chapter shall be recharacterized after the initial characterization in accordance with this section, unless the department approves an alternative recharacterization method. A representative sample of each industrial byproduct shall be recharacterized whenever there is a change in the process that produces the industrial byproduct that could result in a change of the category of the industrial byproduct.

(b) A representative sample of each category 1 industrial byproduct shall be recharacterized in the same manner as specified for the initial characterization once each year. Recharacterization is not required for any category 1 industrial byproduct of which less than 1000 cubic yards were beneficially used or stored for beneficial use in the previous year.

(c) A representative sample of each category 2 industrial byproduct shall be recharacterized in the same manner as specified for the initial characterization once every 2 years. Recharacterization is not required for any category 2 industrial byproduct of which less than 7000 cubic yards were beneficially used or stored for beneficial use during the previous 2-year period.

(d) A representative sample of each category 3 industrial byproduct shall be recharacterized in the same manner as specified for the initial characterization once every 3 years. Recharacterization is not required for any category 3 industrial byproduct of which less than 3000 cubic yards were beneficially used or stored for beneficial use during the previous 3-year period.

(e) A representative sample of each category 4 industrial byproduct shall be recharacterized in the same manner as specified for the initial characterization once every 5 years. Recharacterization is not required for any category 4 industrial byproduct of which less than 5000 cubic yards were beneficially used or stored for beneficial use in the previous 5-year period.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.08 Industrial byproduct categories. The categories of industrial byproducts, characterized in accordance with s. NR 538.06, for beneficial use under this chapter are as follows:

(1) **CATEGORY 1 INDUSTRIAL BYPRODUCTS.** Industrial byproducts that have been determined to contain less than the concentration specified for the parameters listed in Appendix I, Tables 1A and 1B, are category 1 industrial byproducts.

(2) **CATEGORY 2 INDUSTRIAL BYPRODUCTS.** Industrial byproducts that have been determined to contain less than the concentra-

tion specified for the parameters listed in Appendix I, Tables 2A and 2B, and are not category 1 industrial byproducts are category 2 industrial byproducts. If in the total elemental analysis total polycyclic aromatic hydrocarbons exceed 100 mg/kg, department concurrence is necessary prior to classification as a category 2 industrial byproduct. Unless authorized by the department the total elemental analysis for industrial byproducts not listed in Table 2B shall also include aluminum, antimony, barium, boron, cadmium, hexavalent chromium, cobalt, copper, lead, mercury, molybdenum, nickel, phenol, selenium, silver, strontium, thallium, vanadium and zinc.

(3) **CATEGORY 3 INDUSTRIAL BYPRODUCTS.** Industrial byproducts that have been determined to contain less than the concentration specified for the parameters listed in Appendix I, Table 2A, and are not category 1 or 2 industrial byproducts are category 3 industrial byproducts.

(4) **CATEGORY 4 INDUSTRIAL BYPRODUCTS.** Industrial byproducts that have been determined to contain less than the concentration specified for the parameters listed in Appendix I, Table 2, and are not category 1 to 3 industrial byproducts are category 4 industrial byproducts.

(5) **CATEGORY 5 INDUSTRIAL BYPRODUCTS.** Industrial byproducts that have been determined not to be a hazardous waste as defined in s. NR 600.03 (98) and are not category 1 to 4 industrial byproducts are category 5 industrial byproducts.

(6) **CRITERIA AND PROCESS FOR USING CATEGORY STANDARDS.** (a) If a standard for a parameter listed in Appendix I is above the limit of detection and the limit of quantitation, the standard shall be considered to be exceeded if the parameter is reported at or above the standard.

(b) If a standard for a parameter listed in Appendix I is between the limit of detection and the limit of quantitation, inclusive, the standard shall be considered to be exceeded if the parameter is reported at or above the limit of quantitation.

(c) The following applies when a standard for a parameter listed in Appendix I is below the lowest achievable limit of detection:

1. If a parameter is not detected in a sample, the standard will be considered to have been met.

2. If a parameter is reported at or above the limit of detection but below the limit of quantitation, a confirmation analysis shall be conducted. The standard shall be considered to be exceeded if the presence of that parameter has been confirmed by the use of an appropriate analytical method.

3. If a parameter is reported at or above the limit of quantitation, the standard shall be considered to be exceeded.

(7) **CASE SPECIFIC.** The department may review the characterization results for an industrial byproduct in response to a request from the generator of the industrial byproduct and assign a category or categories for that material, or conditionally approve a beneficial use that does not meet the beneficial uses or standards specified in this chapter, on a case specific basis. The department may require additional information prior to a case specific approval. Any exemption or approval granted under this subsection shall be in accordance with the applicable requirements of s. 289.43 (4), (7) and (8), Stats.

Note: The department may revise this rule to add or remove parameters or revise standards if changes in ch. NR 140, or other information warrant modifications.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.10 Beneficial uses. The beneficial uses of industrial byproducts under this chapter which may be exempt from regulation as provided under s. NR 538.12 are:

(1) Raw materials for manufacturing of a product in which the measurable leaching, emissions or decomposition characteristics of the industrial byproduct are substantially eliminated. Products that would meet these criteria include cement, lightweight aggregate, structural or ornamental concrete or ceramic materials, port-

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land cement concrete pavement, asphaltic concrete pavement, roofing materials, plastics, paint, fiberglass, mineral wool, wall-board, plaster and other products as approved by the department.

(2) Agents for physical or chemical stabilization, solidification or other treatment of solid waste that is to be disposed of at a lined landfill having a leachate collection system, or utilized in some other final use approved by the department.

(3) Supplemental fuels that provide energy through controlled burning.

(4) Daily cover or internal structures at lined landfills having a leachate collection system. The industrial byproducts used for this purpose may not contain free liquids. The industrial byproducts used as landfill daily cover may contain not more than 15% of silt and clay sized materials (P200 content), and may not be placed in layers greater than 6 inches thick. In addition the industrial byproducts used as landfill daily cover shall be able to control disease vectors, fires, odors, blowing litter and scavenging without presenting a threat to human health or the environment.

(5) Confined geotechnical fill material in accordance with the project criteria and uses specified in this subsection. If more than 5,000 cubic yards are to be used in an individual project, prior written notification in accordance with s. NR 538.14 (4) and concurrence by the department are needed. If the department does not respond to the notification within 10 business days, concurrence is considered to be granted. Industrial byproducts shall be used in accordance with best management practices. The criteria and uses under this subsection are as follows:

(a) *Base course, subbase or subgrade fill for the construction of commercial, industrial or non-residential institutional buildings.* The industrial byproducts shall be placed underneath the concrete floor slabs and within the frost walls for these buildings. This use of industrial byproducts in the construction of residential buildings is specifically prohibited.

(b) *Base course, subbase or subgrade fill for the construction of a portland cement concrete or asphaltic concrete paved lot.* The placement of the industrial byproduct may not extend more than 4 feet beyond the paved area. Any area where industrial byproducts are not directly beneath the pavement structure shall be sloped to prevent ponding of water, covered with topsoil and seeded as soon after placement as is practical. The use of industrial byproducts as paved lot subbase fill is prohibited in residential areas.

(c) *Base course, subbase or subgrade fill for the construction of a paved federal, state or municipal roadway.* Industrial byproducts placed as part of construction of the paved federal, state or municipal roadway may not extend beyond the subgrade shoulder point. Any area where industrial byproducts are not directly beneath the pavement structure shall be sloped to prevent ponding of water, covered with base course or native soil including topsoil and seeded as soon as practical after placement of the industrial byproduct. The use of industrial byproducts as paved roadway subbase or base fill is prohibited in residential areas, unless used in a roadway designed with a rural type cross-section.

(d) *Utility trench backfill.* The industrial byproducts placed as part of backfill of a trench constructed for the placement of sanitary or storm sewer, non-potable water line, gas main, telecom, communications, electrical or other utility lines shall be beneath a paved roadway, parking lot or other portland cement concrete or asphaltic concrete paved structure. The industrial byproducts may not extend more than 6 feet beyond the pavement structure. Any area where industrial byproducts are not directly beneath the pavement structure shall be sloped to prevent ponding of water, topsoiled and seeded as soon as practical after placement of the industrial byproduct.

(e) *Bridge abutment backfill.* Industrial byproducts placed as part of bridge abutment backfill shall be covered by a roadway structure. Any area where industrial byproducts are not directly beneath the pavement surface shall be sloped to prevent ponding of water, covered with base course or topsoiled and seeded as soon

as practical after placement of the industrial byproduct. The use of industrial byproducts as bridge abutment trench backfill is prohibited in residential areas, unless used in a roadway designed with a rural type cross-section.

(f) *Abandonment of tanks, vaults or tunnels that will provide total encapsulation of the industrial byproduct.* This use does not include the placement of an industrial byproduct in a location where environmental pollution has been identified.

(g) *Slabjacking material.* Industrial byproducts used as a component in a slabjacking material in combination with portland cement, lime or bentonite shall be placed beneath portland cement concrete paved structures to raise areas that have settled. The slabjacking material shall be placed directly from an enclosed transport vehicle. Projects using more than 2 cubic yard of industrial byproduct as a slabjacking material is prohibited in residential areas.

(6) Fully encapsulated transportation facility embankments constructed under the authority of the Wisconsin department of transportation, or a municipality, that meet the criteria in this subsection. Examples include linear roadway sound and sight barrier berm embankments, airport embankments and roadway bridge or overpass embankments. For projects using more than 100,000 cubic yards of industrial byproducts, or with a maximum thickness of industrial byproduct greater than 20 feet, department concurrence shall be obtained prior to initiating the project. These embankments shall be constructed, documented and monitored as follows:

(a) The embankment shall be monitored in accordance with s. NR 538.20 (2).

(b) The embankment shall be covered on the top and sidewalls by 2 feet of recompacted clay, and underlain by a 3-foot thick recompacted clay liner. The recompacted clay base, sidewalls and top cover shall meet the following specifications:

1. A minimum thickness of 3 feet under the entire base and 2 feet on the sidewalls and top compacted to a minimum of 95% standard dry proctor density at a moisture content wet of optimum, based on the characteristics of the appropriate proctor curve for the clay being placed.

2. A classification of CL or CH under the unified soil classification system.

3. A permeability of 1×10^{-7} cm/sec or less, when compacted to 95% standard maximum dry proctor density or greater.

4. An average liquid limit of 25% or greater with no values less than 20%, when tested in accordance with ASTM-D4318-95.

5. An average plasticity index of 17% or greater with no values less than 10%, when tested in accordance with ASTM-D4318-95.

6. A minimum of 50% by weight that passes the 200 sieve.

Note: ASTM-D4318-95 is the American society for testing and materials "Test Method for Liquid Limit, Plastic Limit and Plasticity Index for Soils." Copies of this test procedure can be obtained from the American society for testing and materials (ASTM), 1916 race street, Philadelphia, Pennsylvania, 19103-1187, (215) 299-5400. Copies of these test methods are also available for inspection at the offices of the department, the secretary of state and the revisor of statutes.

(c) Any portion of the clay top cover or sidewalls of the embankment not covered by the pavement structure, which includes base course and pavement, shall be covered by one foot of cover soil that includes a minimum of 4 inches of topsoil.

(d) Documentation testing for the recompacted clay base, sidewalls and top cover shall be as follows:

1. Field density and moisture content testing shall be performed on a uniform grid pattern for each lift of clay placed with the grid pattern offset on each subsequent lift. A lift may not exceed 8 inches in thickness following compaction. One density test shall be performed for each 40,000 ft² of surface area for every 8 inch lift of clay placed on the base and top cover. One density test shall be performed for each 60,000 ft² of surface area for every 8

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inch lift of clay placed on the sideslopes offset on each subsequent lift.

2. A disturbed soil sample shall be obtained for one of every 3 field test locations in subd. 1. and analyzed in a laboratory for atterberg limits and grain size to the 2 micron particle size. An undisturbed soil sample shall be obtained for one of every 9 field test locations in subd. 1. and analyzed for laboratory permeability.

3. A standard proctor curve, ASTM-D698-91, shall be developed for each distinct soil source and type in order that density testing can be correlated to the appropriate soil type.

4. Monitoring devices including headwells, and associated borehole construction shall be documented using the appropriate department forms: monitoring well construction form #4400-113A (rev. 4-90), soil boring log information form #4400-122 (rev. 1-91) and well information form #4400-89 (rev. 1-90).

Note: ASTM-D698-91 is the American society for testing and materials "Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort". Copies of this test procedure can be obtained from the American society for testing and materials (ASTM), 1916 race street, Philadelphia, Pennsylvania 19103-1187, (215) 299-5400. Copies of these test methods are also available for inspection at the offices of the department, the secretary of state and the revisor of statutes.

Note: Copies of these forms may be obtained from the department of natural resources, bureau of waste management, 101 south webster street, natural resources building, p.o. box 7921, Madison, Wisconsin 53707-7921.

(e) Within 90 business days of completion of the construction project, a site construction report shall be prepared and 3 copies sent to the department. Two of these reports shall be submitted to the bureau of waste management and one shall be submitted to the department's field office responsible for the area in which the embankment is located. The report shall include all of the following:

1. A plot plan showing final grades actually achieved in the field, and the location of all soil tests, drainage ditches, surface water drainage control structures, monitoring wells, control points and any other pertinent features.

2. Documentation of the depth of the final cover material utilizing a 200 foot grid pattern. All borings shall be replaced with acceptable material and compacted to proper density. Hand auger or survey data may be used for this documentation.

3. Documentation of the type and quantity of fertilizer, mulch and seed used on the side slopes.

4. Documentation of the quantity and source of the industrial byproduct used in the embankment fill.

5. The final perpendicular cross-sections of the completed embankment. These cross-sections shall indicate the extent of the industrial byproduct placement.

6. Typical detailed drawings of any special design features.

7. An appendix containing all the raw data from the soil testing program.

8. A description of the institutional controls that will be in place to ensure that the structural integrity of the embankment will be maintained, and that any future disturbances of the embankment design features will be repaired.

(f) The final cover and topsoil shall be smoothly graded to enhance positive surface runoff and seeded, fertilized and mulched to establish a thick vegetative growth. Routine maintenance of the embankment slopes shall be performed to insure the integrity of the final soil cover.

(g) A perimeter berm shall be constructed within the limits of the prepared clay base to contain any surface water runoff from the industrial byproduct. The berm shall be maintained throughout the period of industrial byproduct placement.

(h) Measures shall be taken to limit blowing and tracking of the industrial byproduct during transportation to the construction site and placement in the embankment. Measures include keeping the industrial byproduct moist, and compacting it as soon as it is deposited in the fill area.

(i) The department's field office responsible for the area in which the embankment is located shall be contacted at least one

week prior to initiating construction of the clay liner so that arrangements can be made for inspecting the site.

(7) Clay capped and sidewalled transportation facility embankments constructed under the authority of the Wisconsin department of transportation, or a municipality, that meet the criteria in this subsection. Examples include linear roadway sound and sight barrier berm embankments, airport embankments and roadway bridge or overpass embankments. For projects using more than 100,000 cubic yards of industrial byproducts, or with a maximum thickness of industrial byproduct greater than 20 feet, department concurrence shall be obtained prior to initiating the project. The construction, documentation and monitoring of these embankments shall be as described under sub. (6) (b) 2. to (i) and as follows:

(a) The embankment shall be monitored in accordance with s. NR 538.20 (3).

(b) The embankment shall be covered on the top and sidewalls by 2 feet of recompact clay. The sidewalls and top cover shall be a minimum of 2 feet thick. No liner is required.

(8) Unconfined geotechnical fill material used as part of the construction of a building, parking area, utility trench or other structural improvement, where the industrial byproduct is not structurally confined and meets the criteria in this subsection. If more than 200 cubic yards of industrial byproducts are to be beneficially used in an individual project, prior written notification in accordance with s. NR 538.14 (4) and concurrence by the department are needed. If the individual project uses less than 600 cubic yards of industrial byproduct and the department does not respond to the notification within 10 business days, concurrence is considered to be granted. Any area where industrial byproducts are beneficially used as unconfined geotechnical fill shall be sloped to prevent ponding of water, covered with at least 2 feet of native soils including topsoil within 15 business days of placement and seeded as soon after topsoil placement as is practical. The beneficial use of industrial byproducts as an unconfined geotechnical fill is prohibited in residential areas.

(9) Unbonded surface course material used in accordance with the criteria of this subsection. This includes the use of industrial byproducts as a surface course material in unpaved driveways, parking areas and recreation or exercise trails. Industrial byproducts used as surface course shall conform to the requirements of s. 304.2, Wisconsin department of transportation standard specifications for road and bridge construction, and may be placed at a thickness of 3 inches or less and in areas separated by at least a 25 foot vegetated buffer to a navigable surface water. The use of industrial byproducts as unbonded surface course is prohibited in residential areas. If more than 10,000 cubic yards of industrial byproducts are to be used in an individual surface course application, prior written notification in accordance with s. NR 538.14 (4) and concurrence by the department are needed. If the department does not respond to the notification within 10 business days, concurrence is considered to be granted.

(10) Bonded surface course material used in accordance with the criteria of this subsection. This use includes placement of industrial byproducts as a bonded surface course material such as seal coats in roads, driveways, parking areas and recreational or exercise trails. Industrial byproducts used as a bonded surface course shall conform to the requirements of s. 401, Wisconsin department of transportation standard specifications for road and bridge construction, and may not exceed 30 pounds per square yard placed over an asphaltic mastic. Within 48 hours of application of the industrial byproduct, the surface shall be rolled to thoroughly embed these materials into the asphaltic mastic. If more than 10,000 cubic yards of industrial byproducts are to be used in an individual bonded surface course application, prior written notification in accordance with s. NR 538.14 (4) and concurrence by the department are needed. If the department does not respond to

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the notification within 10 business days, concurrence is considered to be granted.

(11) Decorative stone with particle size greater than or equal to 3/4 inches, and with less than 5% silt and clay sized particles, including those adhering to the larger particles. Industrial byproducts used as decorative stone shall conform to the wear and soundness requirements for crushed aggregate base course in s. 304.2.3 and 304.2.4, Wisconsin department of transportation standard specifications for road and bridge construction.

(12) Cold weather road abrasive on roadways with a rural cross-section, including areas with incidental sections of curb and gutter. The winter road abrasives using industrial byproducts, wholly or as part of a mixture of abrasives, shall meet Wisconsin department of transportation gradation recommendations. All particles shall be smaller than 1/4 inch, and the material shall contain no more than 5% silt or clay size particles. The application rate of industrial byproducts used as a winter road abrasive may not exceed 0.4 tons per lane mile per application. These materials may be mixed with sand or other abrasives to achieve this application rate or the Wisconsin department of transportation gradation recommendations contained in the state highway maintenance manual, policy 32.30, effective date January 1, 1991.

Note: Copies of Wisconsin department of transportation specifications for road and bridge construction, and state highway maintenance manual, policy 32.30 can be obtained from the department of natural resources, bureau of waste management, 101 south webster street, natural resources building, p.o. box 7921, Madison, Wisconsin 53707-7921. Copies are also available for inspection at the offices of the revisor of statutes and the secretary of state.

Note: Under s. 30.12 (4), Stats., highway and bridge projects affecting the waters of the state that are carried out under the direction and supervision of the department of transportation are exempt from department permit or approval requirements if accomplished in accordance with interdepartmental liaison procedures established by the department of natural resources and the department of transportation.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.12 Beneficial uses for specific categories of industrial byproducts. (1) Persons who beneficially use category 1 to 5 industrial byproducts in accordance with this section are exempt from licensing under s. 289.31, Stats., and the regulatory requirements under chs. NR 500 to 536.

(2) **GENERAL CRITERIA FOR USES.** (a) All uses shall comply with the performance standards under s. NR 538.04 and the applicable criteria in this section.

(b) Materials that are not category 1 industrial byproducts and that are utilized for any of the uses under s. NR 538.10 (5) to (12) may not be placed below the water table, into permanent standing water or areas that need to be dewatered prior to placement.

(c) All uses shall meet all applicable structural and physical specification and generally accepted engineering practices for the use.

(d) Industrial byproducts incorporated into controlled low strength materials shall be used in accordance with ACI 229R-94.

(e) All beneficial use projects shall be conducted in a manner to minimize windblown dust, odor, tracking and spillage of the industrial byproduct and not to cause nuisance conditions or environmental pollution as defined under s. 289.01 (8), Stats.

Note: ACI 229R-94 is the American concrete institute report "Controlled Low Strength Materials." Copies of this report can be obtained from the American concrete institute, p.o. box 19150, Detroit, Michigan 48219-0150. Copies of this report are also available for inspection at the offices of the department of natural resources, bureau of waste management, 101 south webster street, natural resources building, p.o. box 7921, Madison, Wisconsin 53707-7921. Copies are available for inspection at the offices of the revisor of statutes and the secretary of state.

(3) **USES FOR CATEGORY 1 INDUSTRIAL BYPRODUCTS.** Category 1 industrial byproducts may be utilized for any beneficial uses described under s. NR 538.10 (1) to (12), or other beneficial uses which conform with the exposure assumptions listed in s. NR 720.19 (5) (c) 1. a. and 2. a. Category 1 industrial byproducts are exempt from the notification requirements under s. NR 538.14 (4), the environmental monitoring requirements under s. NR 538.20 and the property owner notification requirements under s. NR 538.22.

(4) **USES FOR CATEGORY 2 INDUSTRIAL BYPRODUCTS.** Category 2 industrial byproducts may be used for any of the beneficial uses described under s. NR 538.10 (1) to (12).

(5) **USES FOR CATEGORY 3 INDUSTRIAL BYPRODUCTS.** Category 3 industrial byproducts may be used for any of the beneficial uses described under s. NR 538.10 (1) to (8).

(6) **USES FOR CATEGORY 4 INDUSTRIAL BYPRODUCTS.** Category 4 industrial byproducts may be used for any of the beneficial uses described under s. NR 538.10 (1) to (6).

(7) **USES FOR CATEGORY 5 INDUSTRIAL BYPRODUCTS.** Category 5 industrial byproducts may be used for any of the beneficial uses described under s. NR 538.10 (1) to (4).

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.14 Reporting. (1) **INITIAL CERTIFICATION.** Prior to beneficial use of industrial byproducts under this chapter, or the establishment of a storage facility as required under s. NR 538.16 (1) (c), each generator, storage facility operator, or their designee shall submit an initial certification form to the department that contains the information listed below. An initial certification form shall be submitted prior to beneficial use in accordance with this chapter for any industrial byproducts not previously classified, for any industrial byproduct for which the classification has changed or for the establishment of a storage facility for industrial byproducts. The initial certification form shall include the following information:

(a) Name and address of generator or storage facility operator.

(b) Name, address and telephone number of designated generator or storage facility operator contact.

(c) A description of each industrial byproduct intended for beneficial use or storage that clearly identifies the process that generated it and an estimate of the volume that could be made available for beneficial use on an annual basis.

(d) The classification of each industrial byproduct to be beneficially used or stored for beneficial use in accordance with s. NR 538.08. Documentation, including test results supporting the classification, shall be included. Storage facilities may provide the name and address of the generators of the industrial byproducts to be stored as an alternative to this documentation.

(e) Authorization for Wisconsin department of natural resources staff to conduct inspections of the facilities generating industrial byproducts being beneficially used under this chapter or storage facilities for these industrial byproducts, and collect samples to verify compliance with this chapter.

(f) Certification by each generator, storage facility operator or their designee, that the information on the form is true and accurate, and that the performance standards of s. NR 538.04 will be met.

Note: Copies of this form may be obtained from the department of natural resources, bureau of waste management, 101 south webster street, natural resources building, p.o. box 7921, Madison, Wisconsin 53707-7921.

(2) **ANNUAL CERTIFICATION.** Each generator of industrial byproducts that have been beneficially used under this chapter, operator of a storage facility for industrial byproducts as required under s. NR 538.16 (1) (c), or their designee, shall submit an annual certification, on a form supplied by the department, that documents the amount of material beneficially used in each category in the previous calendar year and confirms the proper classification of each industrial byproduct. The certification form shall be submitted no later than April 1 of the year following the reporting period. The annual certification form shall include the following information:

(a) Name and address of generator or storage facility operator.

(b) Name, address and telephone number of the designated generator or storage facility operator contact.

(c) A description of each industrial byproduct intended for beneficial use or storage that clearly identifies the process that

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generated it and an estimate of the volume that could be made available for beneficial use on an annual basis.

(d) The volume of each industrial byproduct that was beneficially used, or the change in the volume stored, during the reporting period, identified by category.

(e) The classification of each industrial byproduct in accordance with s. NR 538.08. Documentation of any recharacterization test results required under s. NR 538.06 (4) shall be included. Storage facilities may provide the name and address of the generators of the industrial byproducts to be stored as an alternative to this documentation.

(f) A summary of any problems or obstacles encountered in the beneficial use of the industrial byproducts and the actions taken in response to these concerns.

(g) A summary of the performance, problems and maintenance associated with any storage facilities in accordance with s. NR 538.16 (1) (c).

(h) The environmental monitoring data collected for beneficial use projects in accordance with s. NR 538.20.

(i) Certification by the generator, storage facility operator or their designee, that the information on the form is true and accurate, and that the performance standards of s. NR 538.04 have been met.

Note: Copies of this form may be obtained from the department of natural resources, bureau of waste management, 101 south webster street, natural resources building, p.o. box 7921, Madison, Wisconsin 53707-7921.

(3) EXEMPTION. Subsection (2) does not apply if the volume of the generator's industrial byproducts beneficially used, or stored for future use, during the reporting period was less than 1000 cubic yards.

(4) NOTIFICATION. Each industrial byproduct generator or a person designated by the generator, such as a broker, shall submit written notification to the department prior to initiating a project, where required in s. NR 538.10 (5), (8), (9) or (10). The following information shall be included in the notification:

(a) The name, address and phone number of the contact for the project.

(b) The location of the project and a site description.

(c) The approximate volume of industrial byproduct anticipated to be used in the project.

(d) The anticipated start and end dates for the project.

(e) Identification of the industrial byproduct or byproducts to be used and the category of these materials.

(5) RECORD KEEPING. The generator of an industrial byproduct or their designee, shall maintain records of where their industrial byproduct has been utilized under this chapter for one or more of the beneficial uses described under s. NR 538.10 (5) to (8). These records shall be maintained and be accessible to department staff upon request, for 5 years after the use of the industrial byproduct.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.16 Storage and transportation requirements. (1) STORAGE. Storage of industrial byproducts for beneficial use shall meet the performance standards listed in s. NR 538.04. These storage facilities shall also meet the criteria in this subsection unless exempt under par. (a).

(a) The following industrial byproduct storage facilities are exempt from the requirements of this subsection:

1. Facilities for the storage of industrial byproduct within enclosed structures such as buildings, silos or green boxes.

2. Facilities for the storage of industrial byproducts within a lined area at a licensed engineered landfill that is owned or operated by the user, generator of the byproduct or a person designated by the generator, such as a broker.

3. Facilities for the storage of only category 1 industrial byproducts.

4. Facilities for the storage of category 2 or 3 industrial byproducts that are used for industrial byproduct storage for less than 2 years.

5. Facilities for which the department issues an exemption on a case specific basis.

(b) Storage of industrial byproducts not exempt under par. (a) shall meet all of the following design and operational criteria:

1. The storage area shall incorporate a lined low-permeability, asphalt, concrete, or clay pad and be surrounded by curbs or berms to control surface water run-on and run-off. If a clay pad is used, it shall include protective material over the clay.

2. Means shall be provided for collecting, containing and treating the volume of run-off expected to come in contact with the stored material as a result of the 25-year, 24-hour storm event. Water contact with the stored material shall be minimized, such as by covering with a tarp, where practical.

3. A setback shall be maintained between the stored materials and the edge of the pad to prevent spillage of materials off the pad and allow for vehicle movement completely around stored material.

(c) The operators of storage facilities not exempt under par. (a) shall provide the department an initial and annual certification in accordance with s. NR 538.14, include a summary of storage facility performance, problems and maintenance in the annual certification under s. NR 538.14 (2) (g).

(d) Closure of an industrial byproduct storage facility shall include provisions to remove all visible residues from the storage area.

Note: The discharge of stormwater is regulated under ch. NR 216.

(2) TRANSPORTATION. Vehicles used to transport industrial byproducts intended for beneficial use shall meet both of the following criteria:

(a) Vehicles or containers used to transport industrial byproducts shall be durable and leak-proof. Vehicles and containers shall be repaired on an as needed basis to prevent nuisance conditions from occurring.

(b) Vehicles or containers used to transport industrial byproducts shall be loaded and hauled in such a manner that the contents do not fall, spill or leak. Covers shall be provided to prevent littering and spillage as necessary. Any spilled industrial byproducts shall be properly recovered.

Note: Storage and transportation of industrial byproduct in accordance with this chapter is exempt from the storage and transportation requirements of ch. NR 502 as specified in ss. NR 502.05 (3) (i) and 502.06 (2) (k).

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.18 Public participation. (1) NOTIFICATION. Except as provided in sub. (2), no person may initiate a beneficial use project where the volume of the industrial byproduct to be used is greater than 30,000 cubic yards, or construct or operate a storage facility with a design capacity greater than 30,000 cubic yards, prior to the person giving notice to the affected public and providing for adequate public participation. Unless other forms of public notification and involvement are approved by the department, the notice and public participation process provided by the person intending to initiate a beneficial use project or storage facility shall include, at a minimum, the following:

(a) Placing a public notice in the local newspaper at least 30 business days prior to initiating an industrial byproduct beneficial use project or storage facility, specifying the nature of the beneficial use project or storage facility, including the type and amount of the material to be used or stored, how and where the material will be used, the time frame of the project or storage facility operation, that the person intending to initiate the beneficial use project or storage facility may hold a public informational meeting, and a contact person for the public to request a meeting.

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(b) Holding a public informational meeting, if requested by the public, at which details of the project can be discussed. Department staff may participate in the meeting.

(2) **EXEMPTIONS.** (a) The following beneficial use projects are exempt from the public participation requirements under this section:

1. Beneficial use of category 1 industrial byproducts.
2. Wisconsin department of transportation beneficial use projects that were addressed in the department of transportation's environmental review process.
3. Beneficial use projects at facilities licensed under chs. NR 500 to 536.
4. Beneficial uses described under s. NR 538.10 (1) to (4).

(b) The following beneficial use storage facilities are exempt from the public participation requirements under this section:

1. Storage facilities that are located on the property where the industrial byproducts are generated
2. Storage facilities that are licensed under ch. NR 502.
3. Storage facilities for category 1 industrial byproducts.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.20 Environmental monitoring. (1) Transportation facility embankments described in s. NR 538.10 (6) or (7) shall be monitored in accordance with this section unless otherwise approved by the department. The generator of the industrial byproduct used in the embankment shall be responsible for ensuring that this monitoring is completed. The results of this environmental monitoring shall be included in the annual certification under s. NR 538.14 (2) (b). The department may require environmental monitoring for other beneficial use projects subject to this chapter that do not meet the beneficial uses described in s. NR 538.10.

(2) **FULLY ENCAPSULATED TRANSPORTATION FACILITY EMBANKMENTS.** Environmental monitoring for embankments that are fully encapsulated under s. NR 538.10 (6) shall be conducted as follows:

(a) One headwell shall be installed if less than 50,000 cubic yards of industrial byproducts are used in the embankment. A second headwell shall be installed if 50,000 cubic yards or more of industrial byproducts are used in the embankment.

(b) The head elevation in each headwell shall be monitored twice each year at least 4 months apart. If the head level on the liner exceeds 2 feet, the department shall be notified. This notification shall include an evaluation of the reason for the head level build up and a proposed response to reduce the head level on the liner.

(3) **CAPPED TRANSPORTATION FACILITY EMBANKMENT.** The environmental monitoring for embankments that are capped and not lined under s. NR 538.10 (7), shall be conducted as follows:

(a) One basin lysimeter shall be installed with a collection area of 100 square feet. The lysimeter shall be placed directly below the industrial byproduct, and shall be located so that it will be beneath the thickest placement of the industrial byproduct.

(b) The volume of fluid collected in a basin lysimeter shall be monitored and recorded twice each year at least 4 months apart. If the volume of liquid collected in a basin lysimeter exceeds 375 gallons in one year the department shall be notified. This notification shall include an evaluation as to the reason for the volume of liquid being collected, an analysis of the liquid collected for all the parameters listed Appendix 1, Table 2A and a proposed response to reduce the volume of liquid exfiltrating through the industrial byproduct.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.

NR 538.22 Property owner notification. (1) Written notice shall be provided to the owners of property on which industrial byproducts are utilized under this chapter for one or more of the beneficial uses described under s. NR 538.10 (5) to (8). Category 1 industrial byproducts are exempt from the requirements of this section. The generator of the industrial byproduct, or a person designated by the generator, shall provide the notice in accordance with this section, unless the department approves an alternative notice procedure. This notice shall be on a form provided by the department or in a format approved by the department. Any property owner receiving this notice shall retain this information and provide this information to the next purchaser of the property.

Note: Copies of this form may be obtained from the department or natural resources, bureau of waste management, 101 south Webster street, natural resources building, p.o. box 7921, Madison, Wisconsin 53707-7921.

(2) **SMALL-SIZED BENEFICIAL USE PROJECTS.** For projects that utilize no more than 200 cubic yards of industrial byproducts, the notification shall identify the category, type, volume of industrial byproduct and describe where these materials were placed.

(3) **MEDIUM-SIZED BENEFICIAL USE PROJECTS.** For projects that utilize more than 200 cubic yards but no more than 10,000 cubic yards of industrial byproducts, the notification shall include the information required in sub. (1), and a sketch or drawing that shows the approximate boundaries of the areas where industrial byproducts were used.

(4) **LARGE-SIZED BENEFICIAL USE PROJECTS.** For projects that utilize more than 10,000 cubic yards of industrial byproducts, the notification shall include an affidavit recorded with the register of deeds, within 60 business days of completing the placement of the industrial byproduct, indicating that industrial byproducts were used on the property, and an indication where the information required in subs. (1) and (2), may be obtained.

Note: Under s. 30.12 (4), Stats., highway and bridge projects affecting the waters of the state that are carried out under the direction and supervision of the department of transportation are exempt from department permit or approval requirements if accomplished in accordance with interdepartmental liaison procedures established by the department of natural resources and the department of transportation.

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APPENDIX I

Table 1A

Category 1 ASTM Water Leach Test

Standard (mg/l)	Parameter	Ferrous Foundry Excess System Sand	Ferrous Foundry Slag	Coal Ash	Other ¹
1.5	Aluminum (Al)	X	X	X	X
0.0012	Antimony (Sb)	X	X	X	X
0.005	Arsenic (As)	X	X	X	X
0.4	Barium (Ba)	X	X	X	X
0.0004	Beryllium (Be)	X	X	X	X
0.0005	Cadmium (Cd)	X	X	X	X
125	Chloride (Cl)			X	X
0.010	Chromium, Tot. (Cr)	X	X	X	X
0.130	Copper (Cu)	X	X	X	X
0.040	Total Cyanide	X	X		X
0.8	Fluoride (F)	X	X		X
0.15	Iron (Fe)	X	X	X	X
0.0015	Lead (Pb)	X	X	X	X
.025	Manganese (Mn)	X	X	X	X
0.0002	Mercury (Hg)	X	X	X	X
0.05	Molybdenum (Mo)			X	X
0.020	Nickel (Ni)	X	X	X	X
2.0	Nitrite & Nitrate (NO ₂ +NO ₃ -N)			X	X
1.2	Phenol	X			X
0.010	Selenium (Se)	X	X	X	X
0.010	Silver (Ag)			X	X
125	Sulfate	X	X	X	X
0.0004	Thallium (Tl)	X	X	X	X
2.5	Zinc (Zn)	X	X	X	X

¹ As provided under s. NR 538.06 (1), the testing program for materials other than ferrous foundry system sand, ferrous foundry slag and coal ash must be approved by the department prior to characterization. For other materials the department may modify the list of parameters required to be analyzed for and may establish standards on a material specific basis for additional parameters.

Note: All testing is to be conducted on a representative sample of a single industrial byproduct prior to commingling with other materials, unless otherwise approved by the department.

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Table 1B

Category I Total Elemental Analysis

Standard (mg/kg)	Parameter	Ferrous Foundry Excess System Sand	Ferrous Foundry Slag	Coal Ash	Other ¹
6.3	Antimony (Sb)	X	X	X	X
0.042	Arsenic (As)	X	X	X	X
1100	Barium (Ba)		X	X	X
0.014	Beryllium (Be)	X	X	X	X
1400	Boron (B)			X	X
7.8	Cadmium (Cd)			X	X
14.5	Chromium, Hex. (Cr)	X	X	X	X
50	Lead (Pb)		X	X	X
4.7	Mercury (Hg)			X	X
78	Molybdenum (Mo)			X	X
310	Nickel (Ni)			X	X
9400	Phenol				X
78	Selenium (Se)				X
9400	Silver (Ag)				X
9400	Strontium (Sr)				X
1.3	Thallium (Tl)	X	X	X	X
110	Vanadium (V)			X	X
4700	Zinc (Zn)			X	X
900	Acenaphthene	X		X	X
8.8	Acenaphthylene	X		X	X
5000	Anthracene	X		X	X
0.088	Benz(a)anthracene	X		X	X
0.0088	Benzo(a)pyrene	X		X	X
0.088	Benzo(b)fluoranthene	X		X	X
0.88	Benzo(ghi)perylene	X		X	X
0.88	Benzo(k)fluoranthene	X		X	X
8.8	Chrysene	X		X	X
0.0088	Dibenz(ah)anthracene	X		X	X
600	Fluoranthene	X		X	X
600	Fluorene	X		X	X
0.088	Indeno(123-cd)pyrene	X		X	X
8.8	1-methyl naphthalene	X		X	X
8.8	2-methyl naphthalene	X		X	X
600	Naphthalene	X		X	X
0.88	Phenanthrene	X		X	X
500	Pyrene	X		X	X

¹ As provided under s. NR 538.06 (1), the testing program for materials other than ferrous foundry system sand, ferrous foundry slag and coal ash must be approved by the department prior to characterization. For other materials the department may modify the list of parameters required to be analyzed for and may establish standards on a material specific basis for additional parameters.

Note: All testing is to be conducted on a representative sample of a single industrial byproduct prior to commingling with other materials, unless otherwise approved by the department.

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Table 2A

Category 2 and 3 ASTM Water Leach Test

Standard (mg/l)	Parameter	Ferrous Foundry Excess System Sand	Ferrous Foundry Slag	Coal Ash	Other ¹
15	Aluminum (Al)	X	X	X	X
0.012	Antimony (Sb)	X	X	X	X
0.05	Arsenic (As)	X	X	X	X
4.0	Barium (Ba)	X	X	X	X
0.004	Beryllium (Be)	X	X	X	X
0.005	Cadmium (Cd)	X	X	X	X
1250	Chloride (Cl)				X
0.10	Chromium, Tot. (Cr)	X	X	X	X
1.30	Copper (Cu)				X
0.40	Total Cyanide				X
8.0	Fluoride (F)	X			X
1.5	Iron (Fe)	X	X		X
0.015	Lead (Pb)	X	X	X	X
.25	Manganese (Mn)	X	X	X	X
0.002	Mercury (Hg)	X	X	X	X
0.20	Nickel (Ni)				X
20	Nitrite & Nitrate (NO ₂ +NO ₃ -N)				X
12	Phenol	X			X
0.10	Selenium (Se)	X	X	X	X
0.10	Silver (Ag)			X	X
1250	Sulfate			X	X
0.004	Thallium (Tl)			X	X
25	Zinc (Zn)				X

¹ As provided under s. NR 538.06 (1), the testing program for materials other than ferrous foundry system sand, ferrous foundry slag and coal ash must be approved by the department prior to characterization. For other materials the department may modify the list of parameters required to be analyzed for and may establish standards on a material specific basis for additional parameters.

Note: All testing is to be conducted on a representative sample of a single industrial byproduct prior to commingling with other materials, unless otherwise approved by the department.

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Table 2B

Category 2 Total Elemental Analysis

Standard (mg/kg)	Parameter	Ferrous Foundry Excess System Sand	Ferrous Foundry Slag	Coal Ash	Other ¹
21	Arsenic (As)	X	X	X	X
7	Beryllium (Be)	X	X	X	X
	Acenaphthene	X		X	X
	Acenaphthylene	X		X	X
	Anthracene	X		X	X
44	Benz(a)anthracene	X		X	X
4.4	Benzo(a)pyrene	X		X	X
44	Benzo(b)fluoranthene	X		X	X
	Benzo(ghi)perylene	X		X	X
	Benzo(k)fluoranthene	X		X	X
	Chrysene	X		X	X
4.4	Dibenz(ah)anthracene	X		X	X
	Fluoranthene	X		X	X
	Fluorene	X		X	X
44	Indeno(123-cd)pyrene	X		X	X
	1-methyl naphthalene	X		X	X
	2-methyl naphthalene	X		X	X
	Naphthalene	X		X	X
	Phenanthrene	X		X	X
	Pyrene	X		X	X
100 ²	Total PAHs	X		X	X

¹ As provided under s. NR 538.06 (1), the testing program for materials other than ferrous foundry slag, ferrous foundry slag and coal ash must be approved by the department prior to characterization. Also, for industrial byproducts not listed, department concurrence is necessary prior to classification as a category 2 industrial byproduct. For other materials the department may modify the list of parameters required to be analyzed for and may establish standards on a material specific basis for additional parameters. For these materials the total elemental analysis shall also include aluminum, antimony, barium, boron, cadmium, hexavalent chromium, cobalt, copper, lead, mercury, molybdenum, nickel, phenol, selenium, silver, strontium, thallium, vanadium and zinc, unless otherwise approved by the department.

² If total polycyclic aromatic hydrocarbons exceed 100 mg/kg, department concurrence is necessary prior to classification as a category 2 industrial byproduct.

Note: All testing is to be conducted on a representative sample of a single industrial byproduct prior to commingling with other materials, unless otherwise approved by the department.

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Table 3

Category 4 ASTM Water Leach Test

Standard (mg/l)	Parameter	Ferrous Foundry Excess System Sand	Ferrous Foundry Slag	Coal Ash	Other ¹
0.03	Antimony (Sb)				X
0.25	Arsenic (As)				X
10	Barium (Ba)	X			X
0.02	Beryllium (Be)				X
0.025	Cadmium (Cd)	X	X	X	X
2500	Chloride (Cl)				X
0.5	Chromium, Total (Cr)			X	X
6.5	Copper (Cu)				X
1	Total Cyanide				X
20	Fluoride (F)				X
3	Iron (Fe)	X	X		X
0.075	Lead (Pb)	X	X		X
0.5	Manganese (Mn)				X
0.01	Mercury (Hg)	X	X		X
0.5	Nickel (Ni)				X
50	Nitrite & Nitrate (NO ₂ +NO ₃ -N)				X
30	Phenol				X
0.25	Selenium (Se)			X	X
0.25	Silver (Ag)			X	X
2500	Sulfate			X	X
0.01	Thallium (Tl)				X
30	Zinc (Zn)				X

¹ As provided under s. NR 538.06 (1), the testing program for materials other than ferrous foundry system sand, ferrous foundry slag and coal ash must be approved by the department prior to characterization. For other materials the department may modify the list of parameters required to be analyzed for and may establish standards on a material specific basis for additional parameters.

Notes: All testing is to be conducted on a representative sample of a single industrial byproduct prior to commingling with other materials, unless otherwise approved by the department.

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Table 4

Beneficial Use Methods

	Industrial Byproduct Category				
	5	4	3	2	1
(1) Raw Material for Manufacturing a Product	X	X	X	X	X
(2) Waste Stabilization / Solidification	X	X	X	X	X
(3) Supplemental Fuel Source / Energy Recovery	X	X	X	X	X
(4) Landfill Daily Cover / Internal Structures	X	X	X	X	X
(5) Confined Geotechnical Fill (a) commercial, industrial or institutional building subbase (b) paved lot base, subbase & subgrade fill (c) paved roadway base, subbase & subgrade fill (d) utility trench backfill (e) bridge abutment backfill (f) tank, vault or tunnel abandonment (g) slabjacking material		X	X	X	X
(6) Encapsulated Transportation Facility Embankment		X	X	X	X
(7) Capped Transportation Facility Embankment			X	X	X
(8) Unconfined Geotechnical Fill			X	X	X
(9) Unbonded Surface Course				X	X
(10) Bonded Surface Course				X	X
(11) Decorative Stone				X	X
(12) Cold Weather Road Abrasive				X	X
Note: General beneficial use in accordance with s. NR 538.12 (3)					X

Note: Refer to s. NR 538.10 for description of each beneficial use.

History: Cr. Register, December, 1997, No. 504, eff. 1-1-98.